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Water Pollution In The Yellowstone River Drainage In Montana

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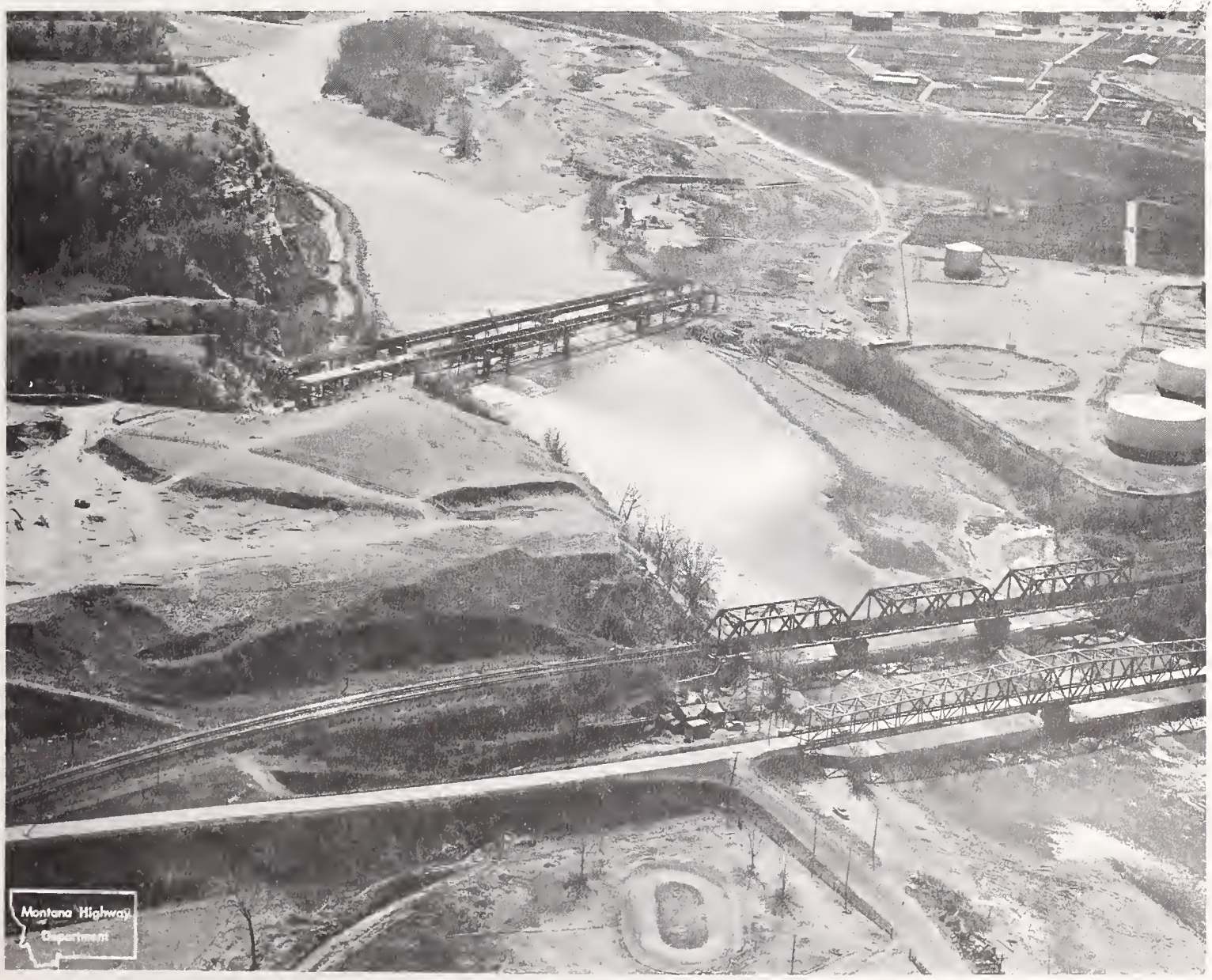

Progress Report No. 63-1
Montana State Board Of Health
Helena, Montana

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Report to Montana Water Pollution Council. December, 1963
WATER POLLUTION IN THE YELLOWSTONE RIVER DRAINAGE OF MONTANA

Progress Report 63-1
Montana State Board of Health

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January 20, 1964

FOREWORD

The Yellowstone River originates in Yellowstone Park and drains nearly 25 percent of Montana's land area as it flows through the state. The river is the principle source of municipal water in the area, is heavily used for irrigation, and receives large amounts of industrial wastes in the Billings area. Taste and odor problems have periodically occurred in domestic water supplies taken from the lower Yellowstone River.

The communities along the river should be complimented for their action in providing adequate sewage treatment plants. The industries have made reductions in wastes reaching the river, but greater treatment is needed in many instances. Construction and active planning for these facilities are underway at the present time. It is planned that the major portion of the treatment needed will be provided during 1964. To aid in this plan, an engineer experienced with waste treatment has been employed and stationed by the State Board of Health at Billings.

By removing the existing pollution from the river, a more desirable drinking water will be obtained, palatable fish will be present in the entire river, and agriculture and industry will receive a better water for their use.

This report is the last of three general reports covering major drainage areas in Montana. The purpose of this report is to outline existing pollution and to catalogue the environmental characteristics of the waters as determined by a stream study during the summer of 1960. A detailed report is being prepared for the Billings area of the Yellowstone River since the major sources of pollution which enter the Yellowstone River originate in this area.

John S. Anderson, M. D.
Executive Officer
Montana State Board of Health

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INTRODUCTION

Municipalities dependent upon Yellowstone River waters have experienced taste and odor problems for many years. Late autumn and winter appear to be the critical periods during which seasonal, minimal, water quantities approach the upper load limits for waste assimilation. Periodic studies have been carried out in the last ten years to determine the sources and extent of pollution entering the Yellowstone River and its tributaries.

In 1951 the U. S. Public Health Service, Division of Water Pollution Control, published a "Missouri River Drainage Basin" report, in which improvements for the abatement of pollution for the Yellowstone River were stressed. This was followed in 1952 by the publication, "Yellowstone River Drainage Basin" by the same source, which was a more complete study on the sources and extent of pollution on this river. It reviewed Montana laws pertaining to pollution and recommended that future water pollution control include enactment of comprehensive legislation, periodic surveillance of streams, improved treatment facilities for waste control and water treatment, etc. "A Comprehensive Program for Control of Water Pollution - Missouri River Drainage Basin" was published in 1953 by the Public Health Service, in which the pollutional status of the Yellowstone River was again reviewed.

The 34th Montana Legislative Assembly, 1955, modified existing laws pertaining to water pollution and created a State Water Pollution Council. The Council, acting through the State Board of Health, was directed to investigate and determine means of eliminating stream pollution, develop a comprehensive plan of pollution abatement, formulate standards of water purity and classification, etc. The Yellowstone River drainage streams were classified during 1958 following a public hearing at Billings. (Appendix D).

The State Boards of Health for North Dakota and Montana in cooperation with the U. S. Department of Health Education and Welfare in November, 1955, investigated taste and odor problems in municipal water supplies along the Yellowstone River drainage. A report, "Yellowstone River Pollution Study", gave recommendations for cleaning up the Yellowstone River.

This report presents information on sixty-six stream sites within the Yellowstone River drainage studied in June and July of 1960 from Tower Junction in Yellowstone Park to below Sidney, Montana. Total river distance was in excess of 500 miles. The main channel of the Yellowstone River, the Clarks Fork River and its major tributary, Rock Creek; and the Big Horn and Little Big Horn Rivers received more attention than did the other tributaries. Other waters such as Fleshman Creek, Boulder River, Stillwater River, Tongue and Powder Rivers were checked at one or two stations only. Yegen Ditch in Billings was considered intensively as it receives and discharges a great quantity of industrial waste material into the Yellowstone River at Billings. This drain-ditch is considered as an open sewer as the major portion of its flow is industrial waste water and storm sewage.

ACKNOWLEDGEMENTS

The survey data for this report was obtained by the State Board of Health summer crew consisting of Dr. Sheldon P. Hayes, Microbiologist of the Weber College, Ogden, Utah, teaching staff and Mr. Hugh R. McLean, State Board of Health chemist. A great amount of assistance during the survey was provided by the City of Billings water and sewage treatment department, particularly by Mr. Elmer T. Bowlen, Chemist.

SUMMARY

1. A total of sixty-six stations were established throughout the Yellowstone River drainage of Montana during the summer of 1960. Chemical, bacteriological and biological samples were collected and analyzed.

2. The dissolved oxygen determinations at all stations exceeded the minimum 5.0 ppm set for Class ABCD streams as determined by day-time sampling. The lowest dissolved oxygen (5.6 ppm) was found on the Yellowstone River below Billings at Huntley during a twenty-four hour survey.

3. The membrane filter technique was employed for coliform bacteria determinations. Approximately one-half of the stations exceeded the classification limits. The majority of these stations were located below municipal sewage outfalls. A number of the communities that were discharging improperly treated sewage have since constructed adequate facilities. Of the twenty-nine sewer systems in the basin serving 108,000 people, nineteen, serving 50,000 people, now have adequate treatment. One city serving 53,000 needs chlorination to supplement its present treatment, and eight communities serving 4,500 need remodeling or replacement of existing facilities. Only one community, and this serves 600 people, has no treatment facilities.

4. When judged by stream bottom organisms, the following portions of the Yellowstone River drainage exhibited favorable ecological conditions: Yellowstone River - From Tower Junction to Laurel, from Hysham to Miles City, and from Terry to Sidney; Stillwater River; Boulder River; upper segments of the Clarks Fork River including Rock Creek; the upper Big Horn River near the Wyoming state line; and the Powder River near the Yellowstone River.

5. Biological environments which reflected polluted conditions were as follows: Yellowstone River - Billings to Worden, below the Big Horn River, and below Miles City; Fleshman Creek in Livingston; Yegen Ditch in Billings; and the Big Horn River near Hardin.

6. Industrial wastes from Billings are probably the principal cause of the pollution indicated below Billings.

7. Improvement of industrial waste treatment facilities is needed in the Billings area.

RECOMMENDATIONS

1. Dissolved oxygen studies be conducted during the year below Billings to determine the effects of organic wastes.

2. Additional coliform bacteria determinations be made on as many streams as is practicable.

3. A vigorous pollution abatement program be conducted in the Billings area.

4. Additional biological studies be made after additional waste treatment facilities have been added.

GENERAL DESCRIPTION OF YELLOWSTONE RIVER DRAINAGE STUDY AREA

The Yellowstone River Basin is located in north central Wyoming, southeastern Montana, and includes a small portion of western North Dakota (Map 1,p35). It is bound by the Rocky Mountains on the west, the Missouri and Musselshell Basins on the north, the Little Missouri and Cheyenne Basins on the east, and by the Platte Basin on the south. The Basin is pear-shaped, having a length of about 440 miles and a maximum width of about 320 miles, the major dimension extending northeasterly and southwesterly. It has a total drainage of 70,400 square miles, of which 35,900 square miles are in Montana, 33,700 square miles in Wyoming, and 740 square miles in North Dakota.

The topography of the Yellowstone Basin is characterized by the rugged foothills and mountain ranges of the Rocky Mountains. The eastern and northerly portions of the Basin extend into the Missouri plateau section of the Great Plains. In this area, occasional flattopped mesas and isolated buttes may rise 500 feet or more above the surrounding plains.

The extreme variation in elevations encountered in this Basin affects wide climatic differences. The growing season varies from 130 days in the plains to as little as 40 days in Yellowstone Park, with an average growing season in the cultivated area of about 120 days.

There are at present only a few riverflow controls in the Yellowstone River drainage of Montana. Yellowtail Dam, upstream from Hardin, Montana, on the Big Horn River is under construction. Allenspur Reservoir above Livingston is under consideration by the Bureau of Reclamation. The Montana State Water Conservation Board has constructed a dam on the Tongue River and another on Red Lodge Creek. In addition to those mentioned there are a number of small reservoirs furnishing water for irrigation projects on tributaries of the Yellowstone, principally in Wyoming.

Yellowstone River

The Yellowstone River leaves Yellowstone National Park near Gardiner, Montana, then flows through a steep winding gorge for about 20 miles and leaves the mountains near Livingston, Montana. From Livingston to Columbus

it winds through a fertile valley having a width of approximately one mile, bordered by sandstone bluffs. Below Columbus the river flows a distance of approximately 400 river miles through a wide valley to its confluence with the Missouri River a few miles upstream from Williston, North Dakota. The river has a total length of approximately 670 river miles with an average gradient of about 32 feet per mile upstream and 7.2 feet per mile downstream from Livingston.

Big Horn River

The Big Horn River, the largest tributary of the Yellowstone, has its origin at the junction of the Popo Agie and Wind Rivers near Riverton, Wyoming. These rivers rise in the Wind River Range and Absaroka Mountains. The Basin is divided topographically into three segments, known in downstream order as the Wind River and Big Horn Basins in Wyoming, and the Lower Big Horn Basin in Montana. The upper portion of the stream traverses a high plateau between the Continental Divide and the Big Horn Mountains. Basin floors are broad, rolling plains cut by numerous eroded valleys and stream courses. The main stem is 461 miles in length and the stream slope averages 6.5 feet per mile. The Basin has a total drainage area of 22,900 square miles, with approximately 18,800 square miles in Wyoming and 4,140 square miles in Montana.

Tongue River

The Tongue River has its source on the northeastern portion of the Big Horn Mountains in Wyoming. The River has a total length of 265 miles and drains an area of 5,300 square miles The average gradient from the headwaters to Ranchester, Wyoming, is 195 feet per mile. The slope from Ranchester to the mouth, a distance of 211 miles, is 6.7 feet per mile. The river drains an area of plains and badlands, flowing through a valley having a width of one to two miles, except for approximately 20 miles of narrow valley near the Wyoming-Montana border. The stream flows into the Yellowstone River at Miles City, Montana. The Tongue River flow varies from the high spring floods and the intermittent flash floods during the summertime to a very low flow during the autumn months.

Powder River

The Powder River rises in the Big Horn and Rattlesnake Mountains in central Wyoming. The main channel is formed near Kaycee, Wyoming, where the South Fork, Middle Fork, and North Fork converge, and has a length of approximately 405 miles. The Powder River drains an area of 13,400 square miles. The river flows through badlands, where it gathers considerable silt. There are many sand bars and mud flats in the river, and the channel is relatively shallow, wide, and unstable. It has been aptly described as a river " a mile wide, a foot deep, too thin to plow, and too thick to drink."

USES OF WATER RESOURCES

An estimated quantity of 40 cfs is distributed to users by municipalities taking water from the Yellowstone Drainage System (Table 1.) The volume of water taken directly from streams by industry greatly exceeds that supplied to municipal systems in the Yellowstone Basin of Montana. The oil refineries, sugar refineries, and steam generating plants constitute the major users of water. The major part of the industrial water is used for cooling purposes and returns to the stream warmer and possibly somewhat polluted.

TABLE I

MUNICIPAL WATER SUPPLIES FROM SURFACE WATERS
IN YELLOWSTONE RIVER BASIN OF MONTANA

Municipality	Source	Treatment
Bearcreek	Bear Creek	None
Big Timber	Boulder River	Infiltration gallery and chlorination
Billings	Yellowstone River	Coagulation, filtration and chlorination
Columbus	Yellowstone River	Settling, filtration and chlorination
Forsyth	Yellowstone River	Coagulation, filtration and chlorination
Fromberg	Clarks Fork River	Infiltration gallery and chlorination
Gardiner	Yellowstone River	Chlorination
Glendive	Yellowstone River	Coagulation and softening, filtration and chlorination
Hardin	Big Horn River	Coagulation, filtration and chlorination
Hysham	Yellowstone River	Infiltration gallery and chlorination
Laurel	Yellowstone River	Coagulation, filtration and chlorination
Livingston	Yellowstone River	Coagulation, filtration and chlorination
Miles City	Yellowstone River	Coagulation and softening, filtration and chlorination
Red Lodge	Rock Creek	Chlorination

Irrigation has been practiced in this Basin since the 1860s. The Bureau of Reclamation and the States are constructing or have constructed vast irrigation systems. The irrigated lands support a large portion of the population and produce many valuable crops, including hay, beans, corn and sugar beets, all of which grow well throughout the area. The State Water Board estimates 500,000 acres are under irrigation in the Yellowstone Basin of Montana. Using an average yearly application rate of 3 acre-feet per acre approximately 5,000 cubic feet per second is used during the 150 day irrigation season. Approximately 50 percent of this is estimated to return to the stream at sometime during the year.

Game fishing is very popular in the upper reaches of the river and its tributaries. Only limited sport fishing exists in the lower portions of the stream where the water is warmer and more turbid. Much of the area, however, because of game fishing and other natural attractions has become a veritable tourists' paradise.

The watering of livestock is also a valuable use of water. Cattle and sheep are raised in large numbers and great dependence is placed on the streams as a source of water for them.

The streams have been and must continue to be used for the ultimate disposal of municipal and industrial wastes.

The important uses of water make it necessary that the streams be maintained relatively free of pollution. Public and industrial water consumers and the tourist industry are dependent upon high quality surface waters.

DISPOSAL OF WASTES

Eleven municipal sewage treatment plants have been constructed in the Yellowstone Basin since 1958. With the proposed installation of chlorination facilities by the City of Billings during 1963 (Table 2) twenty community sewer systems, serving 102,859 people (95 percent) will have adequate treatment. Nine systems having insufficient treatment, serving 5,166 people, will still be considered inadequate (Figure 1.) These systems range in population from 61 to 1,140.

In past years there has been considerable mining activity in the Yellowstone River Basin of Montana, particularly in the Jardine, Red Lodge, Colstrip and Nye areas. Mining activity is now minimal, and there is no known pollution from active mining.

Three oil refineries are located in the Billings area. Treatment from one of these, Farmers Union Central Exchange Refinery, is considered adequate. Industrial waste discharges in the Billings area will be further discussed in a later report. Additional oil refineries are located in the Wyoming portion of the Big Horn River Basin, and one refinery is located on the Clarks Fork Drainage in Wyoming. Of major concern are the phenolic and oily material discharged with water wastes from the oil refineries.

The oil fields in Wyoming and Montana have been sources of pollution. In 1959, during heavy rains, oil sumps were washed out in Elk Basin (Clarks

TABLE 2

Status of Municipal Sewage Treatment
In Yellowstone River Basin of Montana
December 1, 1963

Community	1960 Census Population	Date Treatment Plant Constructed	Discharge to	Mileage	Treatment Provided	Additional Treatment Needed	Community Action
Absarokee	600*	1954	Rosebud Creek	396.3-12-1.0	Imhoff Tank	Lagoons or reduction of sewage flow and chlorination	Preliminary report being prepared
Baker	2,365	1956	Sandstone Creek	127-40-60	Lagoons	None	
Bearcreek	61		Bear Creek	363.7-64-10	Septic Tank	Lagoons	None
Big Timber	1,660	1959	Boulder River	436.3-0.8	Lagoon	None	
Billings	52,851	1950	Yellowstone River	345.5	Primary Treatment	Chlorination	Scheduled for 1963
Bridger	824	1960	Clarks Fork River	363.7-48	Lagoon	None	
Broadus	628		Powder River	146.6-138	None	Lagoons	Preliminary report prepared
Columbus	1,281	1962	Yellowstone River	394	Lagoons	None	
Crow Agency	500*	1962	Little Big Horn River	279.4-40.5-14	Lagoons	None	
Fairview	1,006	1937	Irrigation Drain Ditch to Yellowstone River in North Dakota	20-5	Imhoff Tank	Lagoons	Preliminary report being prepared

Table 2 (continued)

Community	1960 Census Population	Date Treatment Plant Constructed	Discharge to	Mileage	Treatment Provided	Additional Treatment Needed	Community Action
Forsyth	2,032	1960	Yellowstone River	230	Lagoons	None	
Fromberg	367	1962	Clarks Fork River	367-33	Lagoon	None	
Gardiner	425*		Yellowstone River	535	Septic Tank	Lagoons	None
Glendive	7,058	1960	Glendive Creek	89-1.0	Lagoons	None	
Hardin	2,789	1962	Big Horn River	279.4-40.5	Lagoons	None	
Hysham	474		Drain to Yellowstone River	260	Septic Tank	Lagoons	None
Joliet	452	1952	Rock Creek	363.7-18.12	Imhoff Tank	Lagoons or reduction of sewage flow and chlorination	
Lame Deer	200*	1957	Deer Creek		Lagoons	None	
Laurel	4,601	1951 (Improvements 1962)	Yellowstone River	367	Primary and Chlorination	None	
Livingston	8,229	1961	Yellowstone River	476	Primary and Chlorination	None	
Lodge Grass	687	1949	Little Big Horn River	279.4-40.5-77.3	Lagoon	None	
Miles City	9,665	1961	Yellowstone River	179	Lagoons	None	

Table 2 (continued)

Community	1960 Census Population	Date Treatment Plant Constructed	Discharge to	Mileage	Treatment Provided	Additional Treatment Needed	Community Action
Plevna	263	1958	Sandstone Creek	127-40-40	Lagoons	None	
Red Lodge	2,278	1912 (Improved 1948)	Rock Creek	363.7-18-55	Anaerobic & Aerobic Lagoons	None	
Sidney	4,564	1960	Yellowstone River	30.2	Lagoons	None	
Terry	1,140		Yellowstone River	134.5	Septic Tank	Lagoons	Preliminary report prepared
West Glendive	500*	1958	Yellowstone River	91.0	Lagoon	None	
Highland Park (West Glendive)	300*		Yellowstone River	90.0	Imhoff Tank	Connection to West Glendive system	None
Worden	225	1956	Drain to Yellowstone River	322	Lagoons	None	

*Estimated

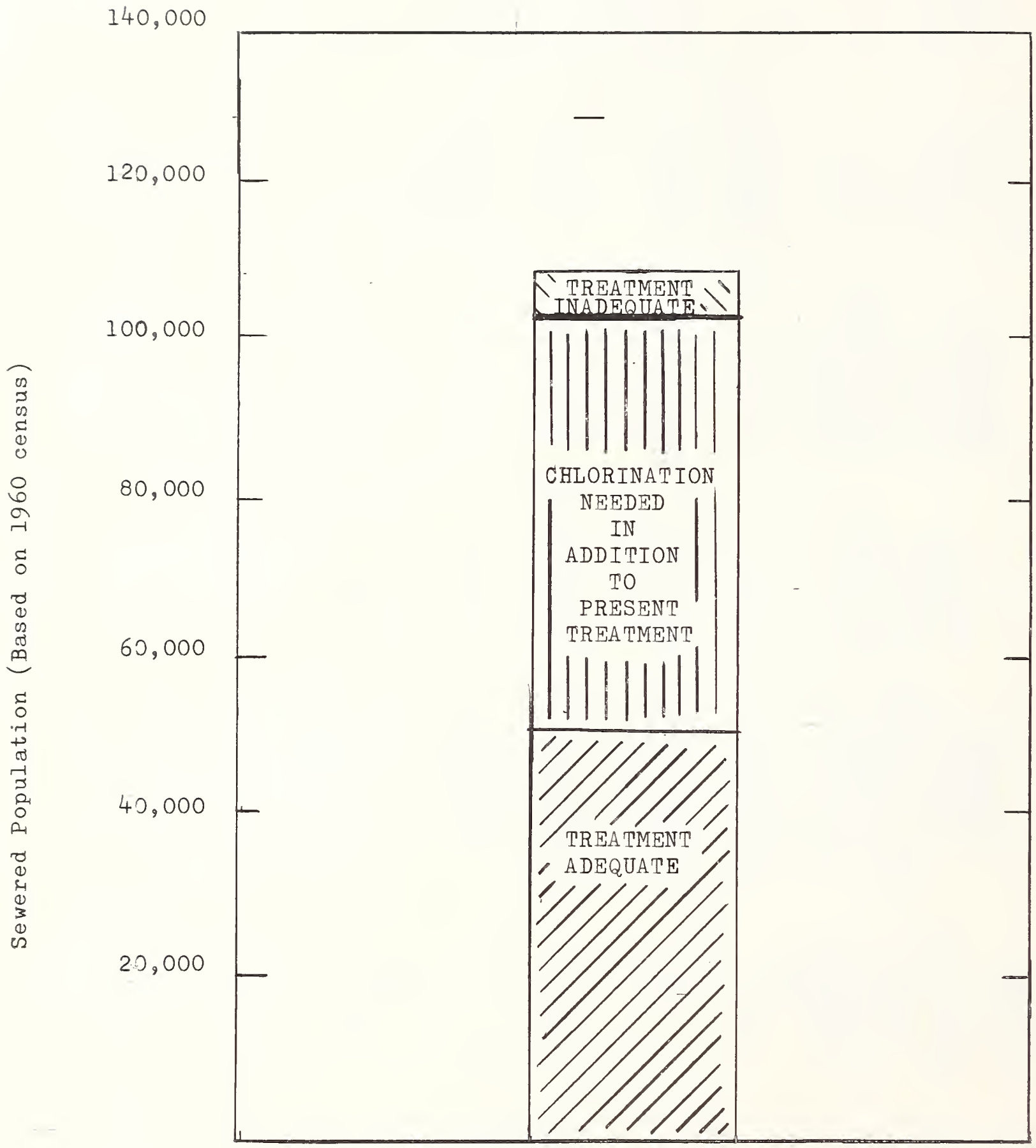


Figure 1
STATUS OF MUNICIPAL SEWAGE TREATMENT
IN
YELLOWSTONE RIVER BASIN OF MONTANA
December 1, 1963

Fork Drainage) along the Wyoming-Montana border, and in 1962 the same thing happened in the Cabin Creek Field near Baker. The Montana Oil and Gas Conservation Commission has taken action in both instances.

Oil pipeline breaks have also been a source of pollution. During 1961 two known breaks occurred - one at Billings of the Glacier pipeline with resulting oil pollution of the Yellowstone River, and the second break in Wyoming in the Big Horn River Drainage near Byron. The Wyoming break created difficult water treatment problems at Hardin.

Railroad maintenance yards (Table 3) are a source of oily wastes. However, these wastes are not believed to be a problem at this time in the Yellowstone River Basin.

Sugar refineries (Table 3) are a source of large amounts of organic wastes. All of the sugar refineries in Montana now have beet pulp driers, which have greatly decreased the organic loading reaching the streams. In addition, each refinery impounds its lime wastes. The refineries generally operate during the months of October, November and December. On January 18, 1961, a break in the dike of a pond storing sugar beet wastes occurred at Worland, Wyoming. Tastes and odors occurred in the water supplies at Hardin and Miles City.

Slaughterhouse and meat packing plants also present water pollution problems. The wastes are high in organic content and unsightly. The two larger meat packing plants are located at Billings (Table 3). Both remove the major part of the blood from the waste flow, but neither has treatment facilities for the remainder of the wastes. Due to the proposed location of the Interstate Highway on portions of the property of the two plants , no action to install treatment has yet been taken. There are several smaller meat packing plants in the Basin, but none of the smaller ones are apparently creating a stream pollution problem.

There are two canneries in the portion of the Yellowstone Basin which is in Montana (Table 3). Wastes from the Red Lodge and Big Horn canneries are discharged to sewers and are treated in municipal sewage treatment plants.

It is estimated that industrial organic wastes added to the Yellowstone River and tributaries in Montana during the time the sugar beet refineries are in operation are equivalent to the untreated organic wastes from 500,000 people.

While complete knowledge is not available regarding the significance of irrigation return water as a source of pollution, it is known that return flows cause an increase in mineral matter, nutrients, temperature, odors, tastes and turbidity in receiving streams. Considerable work has been conducted concerning siltation in the Clarks Fork River by the Pollution Control Biologist assigned to the Board of Health staff by the Fish and Game Department. The study concluded that the silt load contributed to the Clarks Fork River has a detrimental effect upon sport fishing and that the problem originates, for the most part, with private ditch companies located along Sand Coulee Creek above Chance, Montana.

TABLE 3

Status of Wastes Treatment from Major Industries In Yellowstone River Basin of Montana

December 1, 1963

Location	Name	Discharge to	Mileage	Comments
Billings	Continental Oil Co. Refinery	Yegen Ditch to Yellowstone River	346.1-1.3	Biological treatment plant recently installed to treat major waste streams. Biological treatment and retention pond for total waste stream is under construction.
	Humble Oil Co. Refinery	Yellowstone River	342.5	Further reduction of phenolic and oily wastes needed along with retention pond for total waste stream.
	Great Western Sugar Co. Refinery	Yegen Ditch to Yellowstone River	346.1-2.0	Removal of settleable solids from waste stream.
	Pierce Packing Co. (Meats)	Yegen Ditch to Yellowstone River	346.1-0.8	Wastes are not presently treated and treatment should be provided immediately.
	Midland Empire Packing Co. (Meats)	Yegen Ditch to Yellowstone River	346.1-0.7	Wastes are not presently treated and treatment should be provided immediately.
	Big Horn Canning Company	City of Billings Sanitary Sewer	345.5	Adequate
Hardin	Holly Sugar Co. Refinery	Big Horn River	279.39	Further study needed.
Laurel	Farmers' Union Central Exchange Oil Refinery	Yellowstone River	367.1	Adequate

Table 3 (continued)

Location	Name	Discharge to	Mileage	Comments
Laurel	Northern Pacific R.R. Maintenance Shops	Yellowstone River	367	Adequate
Red Lodge	Red Lodge Canning Company	City of Red Lodge Sanitary sewer	363.7-18-55	Removal of carrot tops and floating solids before discharge to city sewer.
Sidney	Holly Sugar Co. Refinery	Yellowstone River	30	Further study needed.

Insecticides present another problem in the Yellowstone Drainage. In 1955 during aerial spraying for spruce budworm control with DDT, a large fish kill occurred below Gardiner. During the summer of 1962 an insecticide was accidentally dumped into a Billings storm sewer with a resultant fish kill below Billings. The proposed 1962 grasshopper control program near the lower Yellowstone River created considerable concern from fish and wildlife people and downstream municipalities. Fortunately, it was determined that the spray program was not needed.

SURVEY INFORMATION PROVIDED

The location and identification of the stations are shown in Appendix A. The river mileages indicated were obtained from the U. S. Geological Survey (USGS) data where available. In other instances where USGS river mileages were not available, the mileage was estimated from the closest point that a USGS mileage was provided. Map 1, Page 36 gives the location of the stations in conjunction with Appendix A.

Bacteriological, chemical and physical data are listed in Appendix B and biological data in Appendix C. Again, the stations can be located by referring to Appendix A and Map 1.

In general, sampling stations were located as follows: -

1. Above and below known sources of pollution being discharged into the stream, with the "below pollution" being located far enough downstream from the effluent to insure thorough mixing with the receiving stream.

2. Above and below the mouth of an entering stream.

3. At various locations in streams known to be free of municipal and industrial pollution.

Ideally samples would be taken at various times throughout the year at each station and a 24-hour composite or individual samples over a period of a day would be taken. Due to personnel available and budget considerations, only single samples were collected at most stations. However, in a few instances where it appeared that dissolved oxygen might be a problem in supporting fish life, dissolved oxygen samples were collected over a 24-hour period and analyzed. Twenty-four hour samples were collected at three stations below Billings. (See Table 4.) Samples for biochemical oxygen demand (BOD) were composited over a 24-hour period at the same time dissolved oxygen determinations were made, and results are also shown in Table 4.

It is preferable where only one sample is taken, that the sample be taken when the stream is being taxed at the maximum. This generally occurs at a time when the flow is at its lowest. Sampling at such a time in most instances was not possible because of the availability of the survey crew only during the summer months. During June and the earlier part of July stream flows are generally close to the maximum. It should, therefore, be recognized that single grab samples for bacteriological, physical and chemical analysis represent only conditions at the time of the sample collection and wide variation from these results at other times could occur. The biological results would not have the wide seasonal variation experienced in chemical and bacteriological results.

TABLE 4

Twenty-four Hour Dissolved Oxygen and Biochemical Oxygen Demand Results at Three Stations below Billings on the Yellowstone River, July 20 - 21, 1960

Station	Time	Temperature (°F)	Dissolved Oxygen ppm	Dissolved Oxygen % saturation	Biochemical Oxygen Demand ppm (24-hour Composite)
Huntley (Station No. 37)	8:00 A.M.	72	6.9	77	
	12 Noon	74	9.4	108	
	4:00 P.M.	77	10.0	119	
	8:00 P.M.	76	8.2	98	2.6
	Midnight	74	6.4	78	
	4:00 A.M.	73	5.6	64	
Custer (Station No. 41)	6:45 A.M.	74	6.3	72	
	10:45 A.M.	77	7.3	87	
	2:45 P.M.	80	7.8	96	
	6:45 P.M.	78	7.1	86	3.7
	10:45 P.M.	77	6.5	77	
	2:45 A.M.	76	6.3	75	
Myers (Station No. 48)	6:00 A.M.	75	6.3	74	
	10:00 A.M.	76	6.5	77	
	2:00 P.M.	79	7.3	89	
	6:00 P.M.	80	7.5	92	3.5
	10:00 P.M.	78	6.9	84	
	2:00 A.M.	77	6.5	77	

Chemical data in most instances during this survey did not provide much information on pollution. Low dissolved oxygen samples would indicate gross pollution. The Most Probable Number (MPN) of coliform bacteria gives a good indication of municipal pollution while biological results are usually the best indicator of industrial pollution and to some extent sewage pollution.

CHEMICAL AND PHYSICAL PROCEDURES AND RESULTS

In the selection of the chemical data to be obtained, the object was to complete the majority of the tests in the field. The time consumed on these chemical tests approximated the time spent on the biological work and as much data as possible was obtained in this period of time.

Additional and more complete chemical analyses can be obtained from the Quality of Water Branch of the USGS for the Big Horn, Tongue, Powder, and Yellowstone Rivers. The Big Horn River at Hardin and the Yellowstone River at Sidney are on the U. S. Public Health Service national water quality network, and extensive data is being obtained from these stations.

Dissolved oxygen content of a body of water is indicative of organic pollution. Stream life uses oxygen in its process of "purifying" organic waste. Since the action of the aquatic community in purifying the waste is a comparatively slow process, the point of lowest dissolved oxygen content may be many miles downstream from the source of pollution.

Dissolved oxygen analytical procedures followed the Winkler Method using the Alsterberg Modification as set forth in "Standard Methods for the Examination of Water, Sewage and Industrial Wastes", 10th Edition.

Dissolved oxygen results are expressed in parts per million (ppm) and percent saturation. Five ppm of dissolved oxygen is considered necessary to support a game fish population such as rainbow trout and is the minimum permitted by the Water Pollution Council Criteria (Appendix E). Percent saturation gives a better indication of organic pollution as saturation of dissolved oxygen varies with water temperature and barometric pressure. Barometric pressure varies with elevation and weather conditions. At sea level dissolved oxygen saturation ranges from 14.6 ppm at 32° F. to 9.2 ppm at 68° F. At constant temperature, saturation is decreased approximately one percent for each 270 foot rise in elevation above sea level. For example, saturation on the Yellowstone River near Gardiner (elevation 5,267 feet) at 68° F. would be 7.6 ppm while the Yellowstone River near Sidney (elevation 1,950 feet) would have a saturation value of 8.5 ppm at the same temperature. In this report, saturation values have been computed using temperature and elevation corrections according to "Standard Methods for the Examination of Water, Sewage, and Industrial Wastes", 10th Edition.

Unfortunately, of any of the chemical results determined, dissolved oxygen is subject to the greatest daily and hourly variation (Figure 2). It is possible to have greater than saturation values (super saturation) during daylight hours and a large decrease from saturation during the night at the same station. This phenomenon is mainly the result of active photosynthesis by aquatic plants, particularly algae. These plants during the day give off oxygen as a by-product and during the night use oxygen. Normally the heavier the organic pollution load, the greater the number of aquatic plants, and, therefore, the greater the variation of dissolved oxygen in the stream.

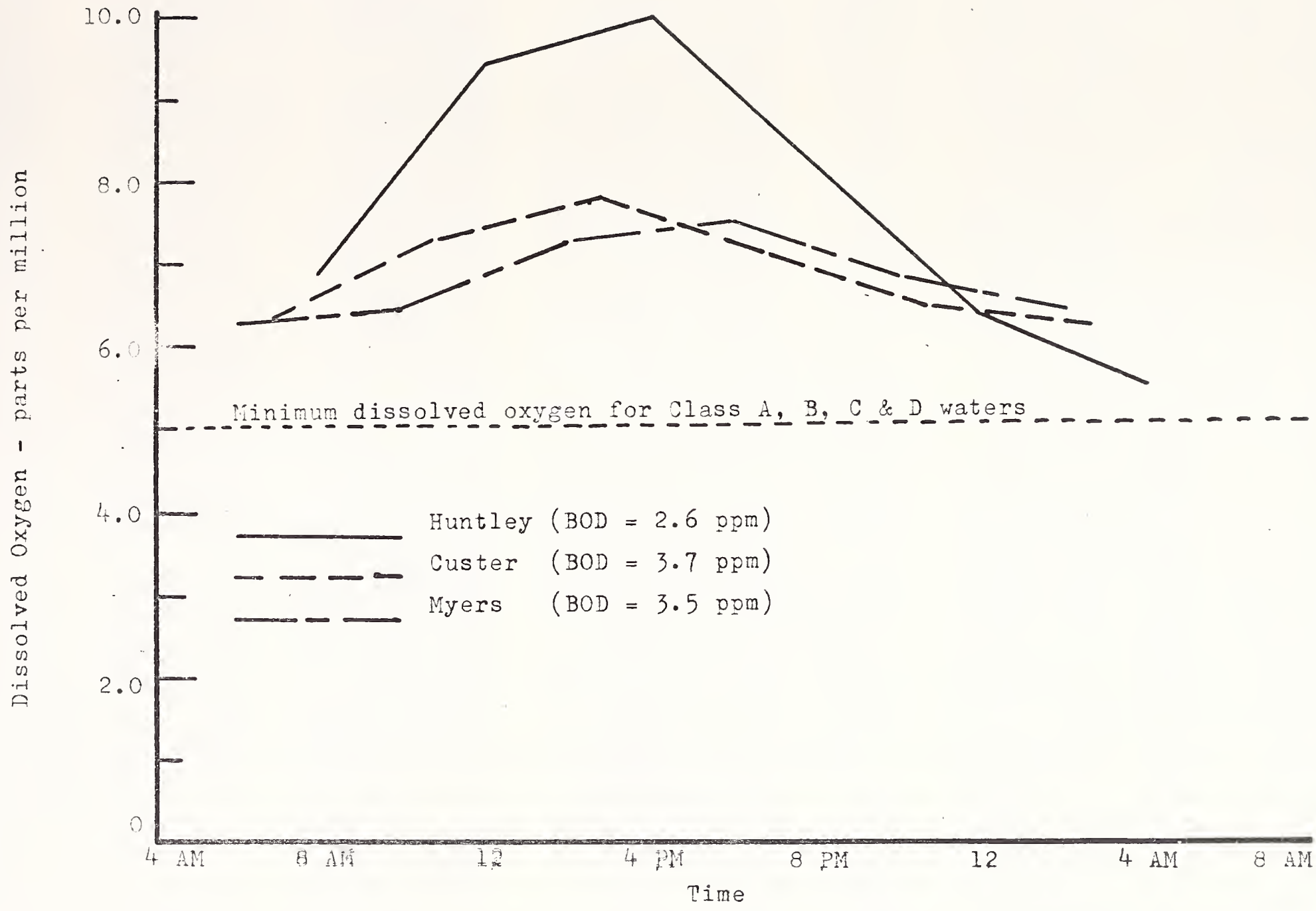


Figure 2 - Twenty-four Hour Dissolved Oxygen Results on the Yellowstone River below Billings, July 20 - 21, 1960.

Since the survey work was usually conducted during daylight hours, the dissolved oxygen values obtained from "grab" samples are probably close to the maximum for that day.

The dissolved oxygen values at all sampling stations were above 5.0 ppm.

Alkalinity, Hardness, Chlorides, Sulfates, and pH

The chemical information given by the survey results for alkalinity, hardness, chlorides, sulfates and pH may have little pollution control value except for industrial wastes, but is of much interest to direct users of the waters. An industry dependent upon water from a surface supply must know its chemical constituents as must a municipality taking the water for its water supply. Fisheries workers use chemical data in comparing streams in their relationship to support fish life.

From Appendix B it can be noted that there are a considerable number of pH (hydrogen ion concentration) results indicating a pH of greater than 8.5, and the results range from 6.9 on Rock Creek (Station 24) to a high of 9.1 on the Yellowstone River at Huntley (Station 37.)

The Water Pollution Council has accepted a pH range of 6.5 to 8.5 (Appendix E) for Class A,B,C, and D waters, that is, waters used as a source for domestic supplies, recreation, and fish and game. On the Yellowstone River Drainage pollution is not indicated as the direct cause of pH values above 8.5. The actual damage to a stream by a pH higher than 8.5 is not known, but there are some reports in the literature that game fish may be restricted. This is particularly true in instances where there is a rapid change to the higher pH, such as a sudden large discharge by an industry of an alkaline waste.

Chlorides will indicate sewage pollution if the ratio of sewage to dilution water is high, as there is a high concentration of chlorides in sewage. Normally, the small increase in chlorides in a stream after sewage is discharged in itself is not harmful to the stream. Conventional sewage treatment does not decrease the chloride content. Chlorides may also indicate pollution from oil fields as water with a high chloride content is sometimes pumped from an oil well along with the oil.

Of course, there are other industries that might discharge large concentrations of chlorides as well as large concentrations of sulfates, alkalinity, hardness, etc. However, in the Yellowstone River Drainage Basin there does not appear to be any significant increase of any of these chemical constituents from industrial discharges, and these chemical results are probably of interest only to the fisheries workers, industries, municipalities, etc. and will not be discussed further in this report because of their doubtful pollutional significance.

The chloride analysis was done by the Mohr method, sulfates by the Tetrahydroxyquinone indicator method, hardness by the Versenate method, and alkalinity by the brom-cresol green-methyl red indicator method.

Temperature

Stream temperature data is provided as this information is needed to calculate dissolved oxygen saturation values. Temperature is also important to stream fisheries workers. Water temperatures were observed using a Taylor pocket thermometer.

Turbidity

The turbidity of water is attributable to suspended and colloidal matter, the effect of which reduces clearness and the penetration of light. The turbidity of the water sample is a measure of the extent to which the intensity of light penetration is reduced by suspended or colloidal matter. The standard unit of turbidity is considered as that produced by one part per million of silica in distilled water. High stream turbidities can be produced by natural runoff, improper irrigation practices and overgrazing, aquatic life such as algae, gravel washing operations, milling operations, etc. The important game fish species in Montana, such as trout, salmon, whitefish, and bass require clean water, and increasingly turbid water reduces the numbers of these fish if the turbidity is of permanent nature. Other fish species, such as sheepshead, catfish and carp seem to thrive in turbid waters. The bottom food organisms for the fish can also be reduced by a layer of sediment on the stream bottom. Because of the nature of the drainage area in the lower Yellowstone River Basin, high turbidities exist.

Turbidities were determined in the field with a U. S. Geological Survey model turbidity tape.

Stream Flow Data

Stream flow measurements were obtained from USGS gaging stations where available. At stations where USGS flows were not available, stream flows were estimated from USGS gaging stations.

Critical conditions, as far as pollution is concerned, normally occur during low flows. Table 5 lists hydrologic data obtained from USGS literature at various gaging stations throughout the Yellowstone Basin in Montana.

BACTERIOLOGICAL PROCEDURES AND RESULTS

The bacteriological content of waters serves as a measure of their public health significance and may be used for establishing water quality as well. Organisms of the coliform group comprise one criterion for water use classifications. The coliforms, per se, are non-pathogenic, but because they are part of the bacteria found in the human intestinal tract as well as in the intestinal tracts of other warm-blooded animals and because isolation and identification of disease-producing organisms from water is time-consuming and often unsatisfactory, these bacteria serve as useful indicators of fecal contamination in water.

The membrane filter technique was used for the bacteriological examination. The procedure permitted water samples to be taken and incubation initiated by field crews. Incubation was completed in the State water laboratory in Helena. The procedure included the addition of water aliquots to an Endo-broth-saturated filter membrane and pad enclosed in sterile ointment tins.

Coliform bacteria numbers per 100 milliliters of water sample collected on the Yellowstone River Drainage, as revealed by the membrane filter technique, are listed in Appendix B. On the assumption that results by this procedure are equivalent in evaluating sanitary significance of waters with standard MPN data, the single samples collected indicated that over one-half the stations examined contained greater coliform organisms than recommended for presently classified streams. Of the locations at which coliform counts exceeded stream classification limits (see Appendix E for stream criteria), several are located below municipal sewage outfalls. These were: Boulder River above Yellowstone River, Rock Creek below Red Lodge and Joliet; the following Yellowstone River sites:

TABLE 5

Hydrological Data (Obtained from USGS 1961 Surface Water Records of Montana)

River & Station	Approximate Stream Mileage Index	Period of Record	Average Discharge for Period of Record, cfs	Extremes: Maximum cfs	Extremes: Maximum Date	Extremes: Minimum cfs	Extremes: Minimum Date
Yellowstone River at Corwin Springs	528	1889-1893 1910-1961	3,014	32,000	6-14-18	389	3-5-37
Yellowstone River at Livingston	484	1897-1905 1928-1932 1937-1961	3,556	30,600	6-20-43	590	1-22-40
Shields River at Clyde Park	473-15	1921-1923 1929-1932 1934-1961	152	4,500	6-5-48	1.8	8-29-35
Boulder River at Big Timber	436.3-2	1947-1953 1955-1961	561	9,480	5-28-56	10	8-26-61
Stillwater River near Absarokee	396.3-10	1935-1961	903	10,600	6-3-48	58	4-2-36
Clarks Fork River at Chance	363.7-78	1921-1961	922	10,900	5-26-28	32	4-26-61
Clarks Fork River at Edgar	363.7-24	1921-1961	1,030	10,900	6-2-36	36	4-22-61
Yellowstone River at Billings	346	1928-1961	6,409	64,800	6-27-41	430	12-12-32
Little Big Horn River near Hardin	279.4-40.0-0.5	1953-1961	181	3,000	3-21-60	0.2	8-7-61
Big Horn River at Bighorn	279.4-0.8	1945-1961	3,558	26,200	6-24-47	275	11-15-59

Table 5, Continued

River & Station	Approximate Stream Mileage Index	Period of Record	Average Discharge for Period of Record. cfs	Extremes: Maximum cfs	Date	Minimum cfs	Date
Tongue River at Miles City	181.5-8	1938-1942 1946-1961	341	12,000	3-6-49	0	July 9-19,1940 Aug. 13,14,1940
Yellowstone River at Miles City	181	1922-1923 1928-1961	10,710	96,300	6-19-44	996	12-14-32
Powder River near Locate	570	1938-1961	570	31,000	2-19-43	0	Several dates
Yellowstone River near Sidney	35	1910-1931 1933-1961	12,740	159,000	6-21-21	470	5-17-61

below Livingston, Columbus, Billings, and Miles City; and the Big Horn River below Hardin. The Laurel sewage treatment plant, when visited, was discharging raw sewage into the Yellowstone River due to sludge clogged pipes. Similarly, Livingston, Columbus, Forsyth, Miles City, Glendive, Sidney and Hardin sewage entered this stream untreated or poorly treated. (All of these cities now treat their sewage.) Possibly other instances might be cited. Streams used freely by livestock might also be anticipated to have coliform counts in excess of recommended levels. On studies of the Milk River below Havre, high coliform counts have been found where irrigation drain water is returned to the river.

The Yellowstone River above Gardiner is classified as an "ACDE" stream. The coliform count of the water sample taken at the Gardiner water plant intake approximated maximum recommended levels for coliform organisms. From Gardiner to the Shields River, which enters the Yellowstone River between Springdale and Big Timber, the Yellowstone River has been placed in Class "BCDE". Water samples indicated apparent effects of Livingston sewage as the "below Livingston" station exceeded coliform organisms counts for this water use category. Fleshman Creek, when examined, was not introducing excessive contamination, suggesting that pollution in this stream as determined by macrobenthos composition is rural in origin.

From Springdale to the North Dakota state line the Yellowstone River has been continued as a "BCDE" stream. Collections revealed that from Springdale to the "above Billings" station, coliform organism counts were within or near the suggested numbers for this type classification. The Boulder and Stillwater Rivers, however, both classed as "ACDE" streams, had higher than the recommended numbers of coliform bacteria for this category. Sewage from the Laurel sewage treatment plant, while introduced into the Yellowstone River with primary treatment, or, as observed, untreated, enters the river via a small lateral channel on the north bank of the river. That this may affect uniform dispersal of organisms is shown by fairly low coliform counts at the "below Laurel" station.

Below Billings, the coliform organisms count was very high. Considering the sewage plant, meat packing plants, and stockyards at Billings, plus biological evidence of pollution entering in Billings, these findings are not unexpected. Rapid overgrowth of non-fecal type organisms on the membrane filter nullified accurate laboratory identification of coliform organisms at many sections below Billings during July. Therefore, additional samples were taken during September. Indications of gross pollution along this section of the river were revealed in stream bottom organism collections. The Yellowstone River at Custer had a coliform count that met recommended criteria.

Water samples from the Big Horn River near and below Hardin had excessive coliform numbers. Stations 43, 45 and 46 were all located below the Hardin outfall sewer. (Sewage lagoons were placed into operation during 1962 at Hardin.)

The Tongue River at Miles City exhibited high coliform numbers. No known domestic sewage is added to the Tongue River in Montana, indicating the contamination is rural in nature. The flow conditions at the time of sampling provide little dilution for rural runoff.

Water from the Yellowstone River below Miles City exhibited high coliform counts. The Miles City sewage lagoon system was not placed into operation until late 1961.

It should be recognized that during this survey, in most instances only one sample was collected at each station. Ideally a much greater number of samples should be collected.

BIOLOGICAL PROCEDURES AND OBSERVATIONS

A. R. Gaufin states in "Biological Problems in Water Pollution" (U.S. Public Health Service - 1957):

"A knowledge of the ecological requirements of aquatic organisms is of outstanding importance in judging the extent of pollution due to organic enrichment in our streams. The species composition of the aquatic population in a given area is determined by the environmental conditions which have prevailed during the developmental period of the organisms involved. If at any time during its development, environmental conditions become lethal for a given organism, that organism will be eliminated even though the unfavorable conditions are of a short duration. The aquatic population which occurs in a given area is, therefore, a representation or indicator of environmental conditions which have prevailed during the life history of the organisms comprising the population.

"It is this property of indicating past environmental conditions, especially the extreme conditions of brief duration, that make macro-invertebrates such valuable indicators of pollution. Most representatives of the group have longer life histories than the micro-benthic fauna and are thus better fitted for indicating past conditions than are the latter organisms. In addition, the larger size and more distinctive morphological characteristics of the macro-invertebrates make them easier to identify under field conditions."

The role of macro-invertebrates as guides to stream ecology as well as to changes in stream status is conditioned by the following: (1) natural distribution of species, (2) movement of a species within a stream, (3) type of stream bottom, (4) nutrients, (5) aquatic flora, (6) turbidity, (7) seasonal changes in water, (8) chemical composition of the waters, i.e. alkalinity, acidity, etc., (9) temperature, oxygen saturation, etc. Inexperienced individuals confronted with the above list of variables affecting animal life on the bottom of streams may feel the list is too extensive to make any generalization. However, repeated observations substantiate the view that certain groups of organisms have a high probability of being found under certain circumstances and not in others. For example, some dipteran species reach high populations in organically enriched waters, i.e, the Tendipedidae (Chironomidae) and rat-tailed maggot show remarkable survival powers in septic to anaerobic conditions and are most prolific in these situations despite the fact that occasionally small numbers may be recovered from aerated waters. Similarly, waters containing large amounts of organic materials support the tremendous population of the sludge worm, Tubifex tubifex. By contrast, where large numbers of mayflies (order Ephemeroptera), caddis-flies (order Trechoptera) and stoneflies - "Salmon flies" (order Plecoptera) appear in a stream, waters are

generally "clean", that is, waters are sparkling, silt absent to small in amount, well aerated, little organic matter in solution or suspension and low concentration of exogenous solutes or suspended materials. The above groups occasionally survive in stream zones of varying degrees other than strictly "clean" water, particularly if there is an addition of clean waters by a contributory stream in the vicinity. Thus, biologists recognize mayflies, caddisflies, and stoneflies as "sensitive or intolerant organisms", meaning that they occur in greatest numbers in clean water habitats; and sludge worms and certain dipterans as "insensitive or tolerant organisms".

The adoption and recognition of sensitive and insensitive faunal species provides a basis for evaluating pollutional status of waters. For the purpose of this report a rather simple method was employed in the analysis of the biological data. This method, generally referred to as the "Percent Sensitive Method", consists of computing the percent sensitive organisms in the samples at any given sampling station. Although commonly used, this method lends itself to some degree of error and such percentages can only be used as a relative index. However, when a particular sample contained less than 50 percent sensitive organisms, it was considered to indicate some degree of pollution.

The validity of the preceding assumptions may be shown from the Clark Fork of the Columbia River studies in which evidence of organic enrichment, i.e., pollution, was detected below an industrial effluent prior to a "fish kill". More recent stream observations, following cooperation by the industry concerned, in which effluent discharge into the stream was discontinued, show river conditions comparable to those existing before the effluent was first introduced.

The four-square-foot bottom sampling method was used as in previous surveys of the Clark Fork and Missouri River drainages. Riffle areas were selected at all sites when available in order to make the data comparable. Ecological circumstances were occasionally such that riffles were not accessible to the field team and where collections were made from other than riffles; such information was noted in the Field Data Records.

Organisms were identified in the field and preserved in 5 percent formaldehyde. For practical reasons the faunal groups were arbitrarily limited to the taxonomical class or order in most instances. Classification beyond this level awaits laboratory examination of the formaldehyde preserved specimens. Total numbers of the groups are summarized in Appendix C which also expresses the findings in terms of sensitive organisms and in terms of population count per square foot. In this report sensitive organisms include mayflies, caddisflies, and stoneflies. Results are shown graphically in Figure 5.

Ephemeroptera were found at all river stations except Worden and Sidney - below Sidney the river is primarily sand and clay margined and no riffle site was located. Trichoptera (caddis-flies) were found at all river points with the exception of Worden to Custer, Hysham, Miles City and Sidney. Plecoptera were found from Tower Junction to the Laurel-Billings river section and were not observed below the Billings area. That Plecoptera are to be potentially found in the lower reaches of the Yellowstone River drainage, however, is shown by their isolation from the Powder River one-half mile above its confluence with the Yellowstone River, about eleven miles west of Terry.

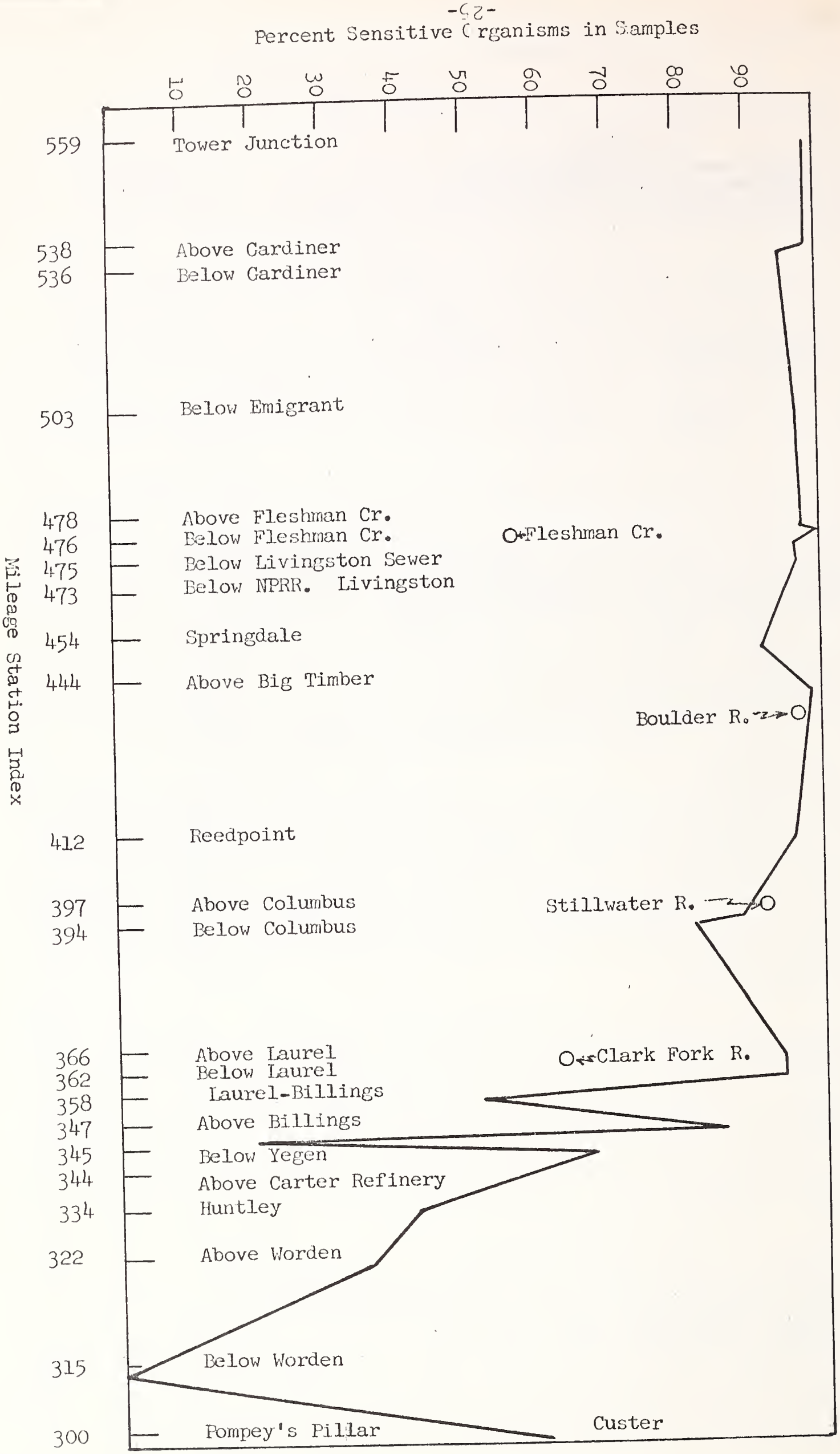
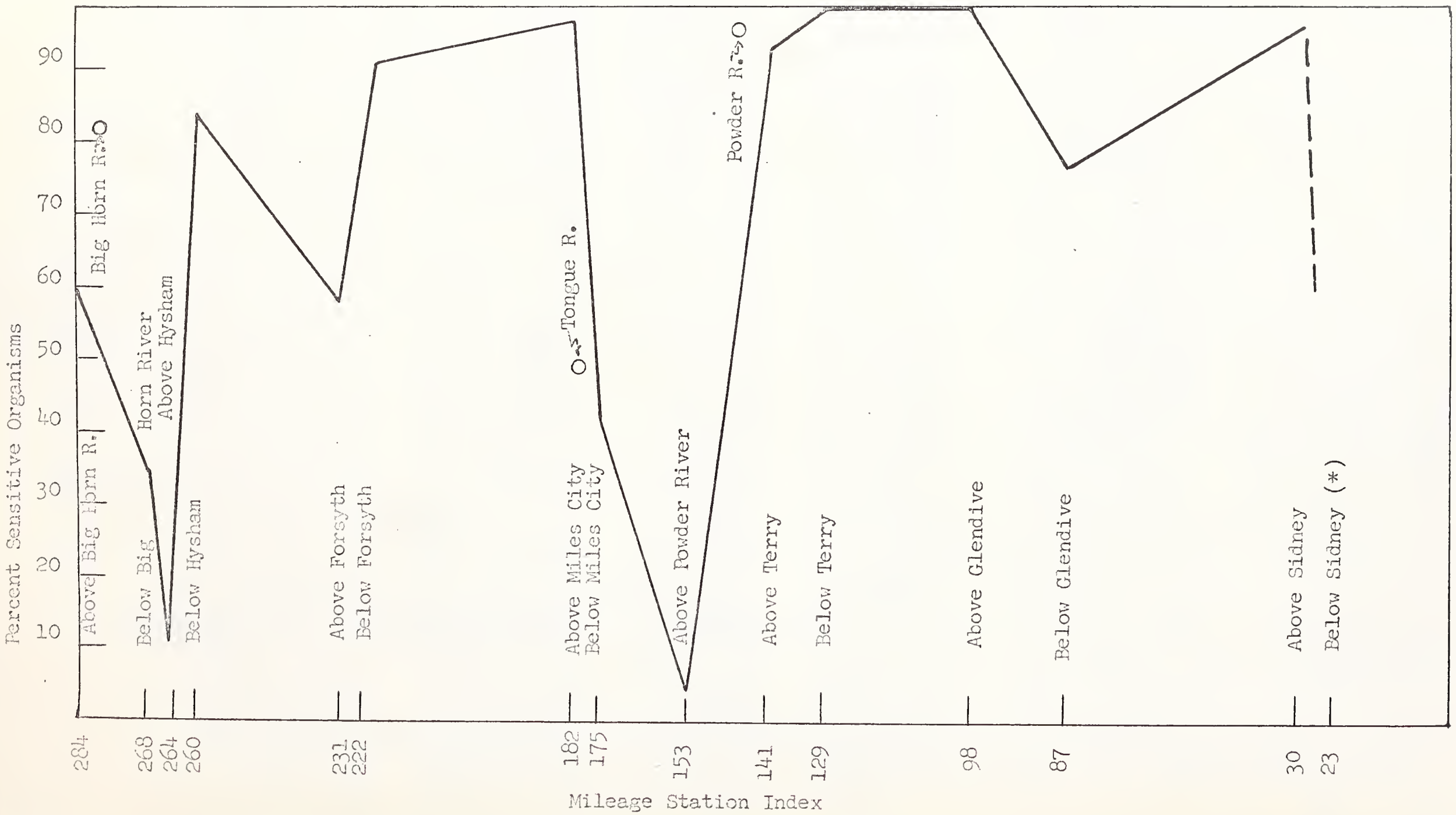


Fig. 3 Percent Sensitive Organisms in Bottom Samples Collected in Yellowstone River Drainage.

Fig. 3 Percent Sensitive Organisms in Bottom Samples Collected in Yellowstone River Drainage (cont



* Riffle area not found. Data obtained not comparable.

Dipterans or true flies were isolated from the majority of stations. Since many dipteran larvae are frequently so small that large numbers of them escape detection by the procedure used, values given for this order must be interpreted with this fact in mind. Maximal faunal population density was found in the Yegen Ditch in the City of Billings above the Great Western Sugar Plant waste effluent outlet where "blood-midge" larvae and rat-tailed maggots accounted for about fifty percent of the diptera recovered.

Oligochaetes, principally Tubificids, were isolated in small numbers along the river from Columbus to the vicinity of the Powder River. Snails were found only in isolated stations such as Fleshman Creek at Livingston, the Yellowstone at Springdale, and below Columbus, Clarks Fork, Rock Creek and Tongue Rivers. Odonata were also comparatively infrequent, being recovered from but seven localities. Fish were frequently observed in the shallows of the streams, often in large numbers. As with the dragonflies, beetle larvae (Coleoptera) constituted a small percentage of forms collected. Leeches (Hirudinae) were seen only in Rock Creek below Joliet.

Upper Yellowstone River

Between Tower Junction and Gardiner, the Yellowstone River receives water from a number of tributaries among which are Bear Creek and the Gardiner River. A reconnaissance examination of Bear Creek was made on June 21, 1960, as a part of a visit intended to evaluate residual effects of mining operations conducted at Jardine several years ago. Visual examination of three separate riffle areas in the vicinity of Jardine revealed a profusion of mayflies, caddis-flies and fewer numbers of stoneflies. Dipterans occurred rarely. Waters were clear and sparkling.

The Yellowstone River above the Gardiner water plant was margined by large boulders and the stream banks were deep and precipitous. The collection site was a poorly defined riffle. Currents along the river margin were eddy-like and the usual bottom organism collecting procedure had to be modified such that insects were "washed" against the screen by foot and leg impelled action of water after the stones had been scrubbed by hand. Nonetheless, the percentage of sensitive organisms were as high as they had been observed further upstream. The proportional insect larval population of the "below Gardiner" station on the Yellowstone River were similar to those at the water plant, suggesting that the septic tank in Gardiner and other potential pollutional sources are at present of no significance when judged by the stream bottom samples.

From Emigrant to the "above Fleshman Creek" station in Livingston the Yellowstone River flows through terrain well covered with timber and grasses. General appearance of the stream remained unchanged from the upper stations. In a like manner recovery of insects from the bottom showed them to be sensitive species. The main channel of the Yellowstone in this region is not used directly by livestock nor is there extensive human habitation along its banks. The topography plus minimal use of waters may contribute to the excellent biological status of the stream in this section of the Yellowstone drainage.

Fleshman Creek enters into the Yellowstone River in Livingston. It receives water from a small intensely irrigated and cultivated area north and west of the city. The land contour is of gentle gradient and the creek wanders and meanders considerably along its courseway. The rate of flow (12 cfs

at the time of this visit) and water velocity were low. The effects of this stream upon the main body of the Yellowstone River was insignificant. In Livingston, the city discharged sewage wastes directly into the Yellowstone River. (Since the survey was completed, a primary sewage treatment plant and chlorination facilities have been placed into operation.) The Northern Pacific Railroad facility contributed a small amount of waste via a ditch downstream from Highway 10-87 bridge. Chemical analysis of "grab" samples of this waste indicates a low oil and phenol content.

On the basis of biological data obtained, Livingston and vicinity did not include pollutional sources resulting in marked changes in the river ecology. The river has a natural barrier from agricultural and domestic wastes which might otherwise have entered from Fleshman Creek in that an old channel of the Yellowstone River has been converted into a lake and lagoon in the city park. Subsequently, the water discharged from the creek appeared to be naturally "purified." The river quality continued much the same to the Springdale section where Mollusca, principally Gastropoda, were found. This may have some significance as these organisms were not taken from the Yellowstone River channel at stations upstream from this point although they had been found in the upper reaches of Fleshman Creek.

The Boulder River enters the Yellowstone River at Big Timber. It is a clear water stream of excellent quality. At the "below Boulder River", "Reedpoint", and "above Columbus" stations on the Yellowstone a continuation of the high biological quality was noted. The very high percentage of sensitive organisms, however, began a downward trend reaching eighty-nine percent at the Columbus water plant intake and decreasing to eighty-two percent at the "below Columbus" station. Percent sensitive organisms reflected an upward trend between Columbus and Laurel, perhaps a result of the somewhat better situation found in the Stillwater River. The Columbus septic tank outlet appeared to be, perhaps, the most probable potential cause of the slight decrease in favorable biological conditions noted at the "below Columbus" station. In lieu of more definitive information other contributary causes must not be excluded. (During 1962, a sewage lagoon system was placed into operation at Columbus).

The Yellowstone River at Laurel when examined in August and November of 1955, revealed plentiful ("common") populations of mayflies (Ameletus) and stoneflies (Claasenia.) Other mayfly species, midges, snipe flies, stonefly species and sludge worms (Tubificidae) were infrequent ("rare"). No caddis-flies were reported at that time. The 1960 summer collection at this station was composed predominatly of mayflies--field identification made species recognition impractical. A few stoneflies were found, large numbers of dipterans (presumably snipe flies), and a single sludge worm. Caddis-flies were found as were snails, neither group being reported in the 1955 survey.

Yellowstone River below Laurel to Billings Stations

Bottom organisms were absent to rare at the "below Laurel" to Billings stations when examined in 1955. Tubificids were abundant. Snails (Physa) and mayfly larvae (Heptagenia) were reported "rare". On July 8th and 9th, 1960, the percentage of sensitive organisms was high at this location; namely, ninety-four percent. Mayflies, caddis-flies, and stoneflies were also present. This was the lower most Yellowstone River station at which stoneflies were recovered in the 1960 summer survey. Between Laurel and Billings, a pronounced decrease in percent sensitive forms was noted -- fifty-one percent -- associated with a rise in sludge worm populations. At the Billings water treatment plant

intake, the mayfly counts were high and more caddis-fly numbers evident. These conditions are reflected in the trough and peak for these locations seen in Figure 3. The 1960 observations show definite improvement in stream ecology since 1955 for the Laurel-Billings area. One may assume that the once gross pollution entering the Yellowstone River in the vicinity of Laurel has been materially reduced during the interim. (The Farmers' Union Oil Refinery constructed major waste treatment facilities during this period.)

Yegen Ditch in Billings

The Yegen Ditch is of special concern because it is one of the principle industrial waste outlets to the Yellowstone River in the Billings vicinity. The first major source of pollution to enter the Yegen Ditch has its origin from the Great Western Sugar Refinery near 27th and State Streets in Billings. The sugar company was not in operation at the time of the July 9th and 11th, 1960, visit. Above the sugar company outlet the ditch contained very little water. Organisms were living in a placid, slow-moving aquatic habitat. Those recovered were typical of water environment reflecting these conditions, namely, diptera. The latter were largely blood midge larvae and rat-tailed maggots (*Tubifera*). The most dense animal population encountered during the 1960 summer survey was obtained at this location.

At the "below Great Western Sugar Company and above Conoco Oil Refinery" station insect numbers were about one-half those found above the sugar company outlet. The insect larvae were almost entirely Diptera, and the samples were 99 percent tolerant species.

The ditch was devoid of organisms at the "below Conoco Oil Refinery" sampling station. The ditch bottom was covered with a thick, black, tarry residue and marginal plants and debris were covered with a white crustose deposit.

Additional water enters the Yegen Ditch between the Conoco outlet and the Pierce Packing Company effluent. Located along the ditch in this section are the Billings Public Stockyards and stockyards of the Pierce Packing Company. Increased flow in the ditch at this point suggests irrigation overflow or storm drainage from the vicinity of South 16th to South 18th Streets.

The Yegen Ditch was not examined biologically below the Pierce Packing Company effluent due to the generally malodorous condition, presence of blood and suspended solids, and the depth of sludge and organic sediments on the ditch bottom. The effluent from the Pierce Packing Company contained an excessive amount of blood and great quantities of floating grease, some masses of which reached aggregates several inches in diameter. Disturbance of the ditch floor at the mouth of the effluent discharge resulted in the emission of decomposition odors and flaky material, resembling partially decomposed paunch manure. Visual examination of the ditch below this point and above the Midland Packing Company property showed a large number of grease aggregates floating downstream. No similar grease masses were observed arising from the Midland Packing Company wastes.

The Midland Packing Company waste outlets were examined visually July 13th, 1960. At this time, four pipes approximately six inches in diameter

were discharging plant wastes (some of which were red tinged) into the Yegen Ditch. While the survey crew was on the Midland Packing Company premises, a workman threw a considerable volume of dried hay and other debris into the ditch.

Yellowstone River Below Billings

Between the Yegen Ditch entry into the Yellowstone River at the Highway 87 bridge and the discharge of sewage from the Billings sewage treatment plant, a distance of approximately one-half mile, the northside of the river is smeared with foul, rancid grease deposits varying from four to twelve inches or more in depth. Grease particles, some of which exceeded four inches in diameter, were seen floating downstream along the river margin.

Examination of the Yellowstone River at the "below Yegen Ditch" station indicated nineteen percent sensitive organisms living on the stream bottom--only two mayflies being recovered at this station. Dipterans and sludge worms accounted for the other insects recovered. Such findings amplify the magnitude of pollutants contributed to the Yellowstone River by industries adjoining the Yegen Ditch and highlight the necessity for pollution abatement being vigorously promoted.

The Billings municipal sewage treatment plant effluent enters the Yellowstone River about one-half mile downstream from the mouth of the Yegen Ditch. The plant provides primary treatment only. Below the Billings sewage treatment plant and opposite the Humble Oil Refinery, sixty percent sensitive organisms were present, consisting of mayflies, caddis-flies, dipterans and sludge worms. This represented a decrease of tolerant species from the station upstream ("below Yegen Ditch"). The increase of sensitive species may have been due to the invasion of clean water organisms from upper stations during high water along with the greater amounts of dilution water provided during the spring run-off. Also the wastes at the "below Yegen Ditch" station are very poorly mixed with the receiving stream. There was a considerable deposit of slime in the riffle area and decomposition odors were prevalent at this station.

The Yellowstone River at the Humble Oil Refinery waste outlet was examined on July 13, 1960. Reconnaissance samples in the river above the discharge revealed an abundance of mayflies and some caddis-flies. Rocks in the discharge from the oil refinery and in the river immediately below the waste outlet were devoid of insect forms.

In an effort to establish possible biological effects that the Humble Oil Refinery wastes might have upon the Yellowstone River, the subsequent downstream station was taken at the Huntley bridge. Here the water emitted a definite oil refinery odor. In the stream, 58 percent insensitive organisms were recovered, mostly dipterans and tubificid worms. Caddis-flies were rare. When this station was examined in 1955, no stream bottom organisms were reported. This represented maximally unfavorable ecological conditions in which no macrobenthic forms could exist. The 1960 summer observations suggest some improvement in water quality at the Huntley station. These changes may be correlated with the active stream pollution abatement efforts expended in the Laurel-Billings areas since the 1955 study and offers positive support for continuation of those efforts.

Yellowstone River from Worden to Custer

The Yellowstone River above Worden had thirty-six percent sensitive organisms on the stream bottom. Mayflies were fewer in number than at Huntley as were diptera and sludge worms, the only other groups of organisms present. The 1955 study did not include the Yellowstone River in this section. Below Worden, tolerant organisms completely dominated the collections. The composition was almost exclusively sludge worms.

At the "between Pompeys Pillar and Custer" station, the percent of sensitive bottom forms was sixty. Again mayflies predominated the insect populations. As at the "above Worden" station, the other two groups of organisms were sludge worms and dipterans. Similar findings were made of the Yellowstone River at the Custer County road bridge, namely, mayflies, dipterans and tubificids plus two dragonfly larvae.

Figure 3 indicates a definite deterioration in Yellowstone River ecology between the Billings and the Worden area, followed by a section of river with considerably better ecological conditions. While it is possible that unknown pollutional sources may occur along the Yellowstone from Billings to the Worden vicinity, the most obvious sources are the industrial waste contributors at Billings. The rate of recovery from poor to favorable ecology for streams the size of the Yellowstone River is known to be rapid. In 1960 several sections of the river were in better condition than in 1955. Equally apparent from the 1960 study is the strong suggestion that pollution of the river in this general section is a major problem necessitating a continued program of research and control if the river is to meet present stream classification criteria.

Yellowstone River below the Big Horn River to Miles City

Pollution sensitive organisms made up thirty-four percent of bottom fauna samples from the Yellowstone River below the entry of the Big Horn River. The total faunal number was low. Sludge worms and dipterans were equal in number to the mayflies here. Considerable silt deposits covered stones in the riffle area used for study. Water turbidity was also high at the "above Hysham" location, and sensitive species were eleven percent of the total population. Tubificids accounted for most of the animals recovered at the locality with diptera and mayflies being the other groups present.

Below Hysham a definite upward trend was noted in stream conditions. Eighty-four percent of the forms recovered were sensitive species with mayflies, caddis-flies, sludge worms and gastropods being predominant. Above Forsyth fifty-eight percent of the forms found were sensitive species. In the absence of known industrial activity contributing to pollution of the river along this section and in view of the fact that there is considerable farming done along the river margins, the fluctuation in river ecology at this point may be attributed to possible irrigation run-off and other unknown causes. At the "below Forsyth" and the "above Miles City" locations, the Yellowstone River was in excellent biological condition. Sensitive species represented ninety-one and ninety-seven percent of the bottom fauna populations at these places. Caddis-flies, diptera and sludge worms were present at the former station and absent from the latter.

Yellowstone River from Miles City to Sidney

The Yellowstone River "below Miles City" station contained forty-two per-cent sensitive organisms. Faunal groups present were similar to those found at the "below Hysham" station, the difference between the two stations being fewer mayflies. Above the Powder River the Yellowstone River was in very poor ecological condition in which only five per cent of the animals found were sensitive forms. Total population numbers were also low and tubificids were most common. Miles City had no sewage treatment facilities at the time of the survey. (A sewage lagoon system was placed into operation during 1962). It is possible that the Miles City sewage along with agricultural irrigation returns to the river plus high turbidities contributed by the Tongue River were responsible for the poor ecological conditions of the river found at these stations.

In the 1955 Yellowstone River report, mayfly nymphs (Choroterpes sp.) were given as "rare" and the only forms listed for the river at Miles City.

Stations from below the Powder River to Sidney revealed very favorable aquatic conditions in which in each instance sensitive organisms percentages were more than ninety per cent. An exception was the "below Glendive" station at which point sensitive organisms accounted for seventy-seven percent of the species recovered. These stations were "below Powder River", "below Terry", "above Glendive", "below Glendive" and "above Sidney."

The 1955 study on the Yellowstone indicated the only forms present were mayfly nymphs (Habrophlebia sp.) in the river at Glendive. Over the fifty road miles between Glendive and Sidney the river drops less than 120 feet. Consequently the river current is very slow, silt deposits and mud banks are common, and good riffle collecting sites were difficult to find. At the "below Sidney" station, the river bank was soft sand and silt. Repeated "sweeping" action of the collecting screen revealed no organisms present under these circumstances. The last station attempted adjacent to Richland County Park in the north outskirts of Sidney was nearly identical to the last station mentioned and no organisms were found. The river through this section of its drainage has numerous mud-sand islands reminiscent of those seen in the Missouri River near North Dakota in 1957.

The data obtained in the 1960 summer survey would indicate that, assuming the 1955 study information and the former investigations to be comparable and reliable, the Yellowstone River drainage from Laurel to below Sidney has become increasingly better ecologically, particularly from Laurel to Billings, Hysham to above Miles City, and from the mouth of the Powder River to Sidney. As indicated earlier in this report, extremely poor biological conditions are evident from Billings to below Worden, below the mouth of the Big Horn, and below Miles City.

Yellowstone River Tributaries:

Fleshman Creek at Livingston:

Fleshman Creek originates north and west of Livingston. When seen, it had about twelve cubic feet per second of water flowing in it. The stream drains a small valley lined with cultivated fields on either side, through which it twists, turns, and presents a series of convoluted, spreading causeways used frequently and often by livestock. It continues through the

City of Livingston to terminate in a small lake which actually serves in many ways as a small lagoon. Above Livingston, Fleshman Creek contained fifty-four per cent sensitive organisms and at the south 9th Street bridge in Livingston, twenty-four per cent sensitive species. Above the city, molluscs were the predominate group whereas in the city diptera and tubificids were most common. Beetle larvae, stoneflies, caddis-flies, and mayflies were other forms represented. Biologically, Fleshman Creek presented a very poor ecological picture. Low stream flow, slow current, tortuous courseway, and ample opportunity for agricultural and domestic waste disposal all seemed to have combined to contribute to a polluted stream.

Boulder River At Big Timber:

The Boulder River enters the Yellowstone River at Big Timber and when examined was in extremely good ecological condition. Total animal numbers were somewhat higher above the Big Timber sewage lagoon outlet than below it and at the latter location there were beetle larvae and dipterans recovered which were not found above the lagoon. At each location the waters were clear, and cool and swift--additional qualities of high stream quality.

Stillwater River at Columbus:

Biologically this stream was much like the Boulder River, ninety-two percent sensitive organisms present with mayflies, stoneflies, caddis flies, beetle larva, diptera, and a few molluscans. Also like the Boulder River it was clear, had an abundance of riffle areas, and presented the appearance of a typical clean stream.

Clarks Fork River Including Rock Creek:

Rock Creek originates southwest of Red Lodge. Above Red Lodge this stream contained eighty-three percent sensitive organisms, included in which were the most diverse number of mayfly species of any station examined during the 1960 summer survey. Caddis flies were also abundant. This station also exhibited the largest number of beetle larvae found at any station in 1960. Dipterans were also common. Below Red Lodge there were sixty-eight percent sensitive organisms. Dipterans and caddis flies were much more prevalent here than above the town. Above Joliet, Rock Creek had ninety percent sensitive forms and a much more intensive faunal population than at the "Below Red Lodge" station. Mayflies, caddis flies, dipterans, sludge worms, gastropods, and beetle larvae were all represented. Below Joliet organism numbers had decreased considerably and sensitive forms accounted for seventy-seven percent of the fauna recovered. Numerous small side streams enter into the main channel of Rock Creek along this section. Livestock use the waters extensively and a considerable quantity of water is diverted for irrigation.

The Clarks Fork River begins in northwest part of Wyoming and enters Montana at Chance as a clear water stream composed exclusively of sensitive species although total insect numbers were quite low. The Big Sand Coulee also originating in Wyoming contributes a massive quantity of silt laden irrigation water which immediately produces marked turbidity of this stream. Above and Below Bridger and at Edgar, the Clarks Fork River, while somewhat turbid, was in good biological condition and contained ninety-four to ninety-five percent sensitive organisms. Near Bridger the insect populations were

high while at Edgar the numbers present were about one-sixth to one-seventh those at the upper stream stations. Mayflies, caddis-flies and diptera were most prevalent. Stoneflies were few in number. At Silesia the Clark Fork had sixty-nine percent sensitive organisms in a low faunal population. Diptera, sludge worms and mollusca constituting the remaining species. Waters from the Clarks Fork River may exert a derogatory effect upon the ecology of the Yellowstone River below Laurel.

Big Horn River and Little Big Horn River:

The Big Horn River originates in north central Wyoming and enters Montana northeast of Lovell, Wyoming. Draining an area of over 22,000 square miles, the Big Horn River traverses extensive plains lands formed from ancient lake beds. Like the Milk River it is characteristically turbid. When examined near old Fort Smith the Big Horn River had seventy-six percent sensitive organisms composed of mayflies, caddis-flies and diptera. Profuse moss and algal growth covered rocks in the riffle areas. The stream is the principal source of water for irrigated lands and for livestock use throughout its length in Montana.

The "above Little Big Horn River" station contained fifty percent sensitive species with numbers of organisms quite low (ten per square foot). Like the upper station on this stream the fauna was composed of mayflies, caddis-flies and diptera. The Big Horn River connects with the Little Big Horn River at Hardin. On the Little Big Horn River above the Big Horn River the waters contained eighty-three percent sensitive organisms. For the most part, caddis-flies accounted for the increase in the numbers of sensitive organisms found here as compared with the Big Horn River. Flow in the Little Big Horn River was low but the water was much less turbid than the Big Horn River.

In the 1955 Yellowstone River study dragonfly larvae (Gomphus) were the only bottom organisms recovered from the Big Horn River at Hardin, and they were reported as "rare". In the same report, these same forms plus a few mayfly nymphs and caddis-flies were stated to be "rare". No other organisms were listed for these two rivers. Data obtained in the 1960 survey indicates that either (1) there is a definite seasonal fluctuation in both numbers and species of bottom fauna, or (2) the streams are in a period of returning to more favorable ecological conditions.

The Big Horn River "below Hardin and above Holly Sugar Company" station revealed fifty-eight percent sensitive organisms with the same three groups of animals present as were found at the above stations namely, mayflies, caddis-flies and dipterans. Waters also were turbid as at previous locations on this river. The station was situated just above the Holly Sugar Company water pumping plant which was not in operation at the time the stream examinations were conducted. (The City of Hardin since the survey has placed into operation its sewage lagoon system.)

At the "below Hardin and below Holly Sugar Company" station on the Big Horn River bottom fauna was composed largely of caddis-flies with a few mayflies and diptera with a total of eighty-five percent sensitive organisms present.

Efforts to locate an appropriate sampling station on the Big Horn River immediately above the Yellowstone River were not successful.

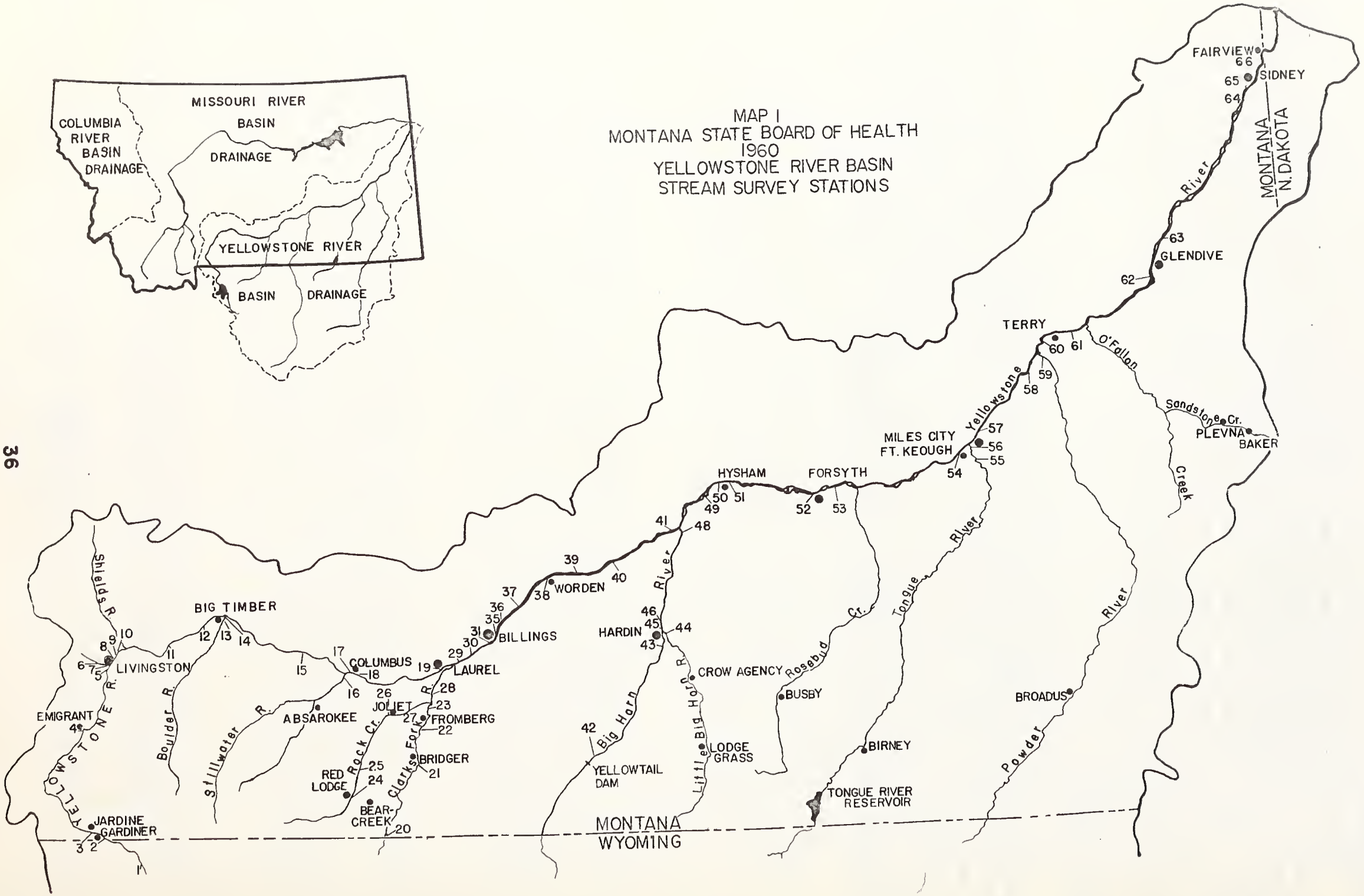
Tongue River:

The Tongue River flow enters the Yellowstone River at Miles City. At the "above Miles City" station it contained fifty percent sensitive organisms composed of dipterans, caddis-flies and mayflies. Waters were turbid, sluggish, and riffle area rocks were covered with extensive slime and algal growth. The stream was used freely by livestock. Excessive silt and mud bars of several feet in depth covered the lower reaches of the river near its mouth and prevented appropriate biological collections from being made (July 16th, 1960). The Tongue River was not included in the 1955 Yellowstone River survey.

Powder River:

The Powder River has a length of over 400 miles and passes along badlands with silt and sand bars of varying widths and unstable in nature. However, by the time the river reaches the Yellowstone west of Terry it has lost much of the silt load, probably due to settling action, and contained, when examined, ninety-seven percent sensitive organisms. The latter were predominantly caddis-flies with mayflies, stoneflies, a few dragon flies and diptera. Note should be made that this was the only station below the Billings area in which stoneflies were recovered.

MAP I
MONTANA STATE BOARD OF HEALTH
1960
YELLOWSTONE RIVER BASIN
STREAM SURVEY STATIONS



Appendix A
Locations and descriptions of sampling stations established during the summer of 1960 on the Yellowstone River Drainage System and their corresponding Yellowstone River Drainage Indices.

YELLOWSTONE RIVER DRAINAGE SYSTEM

STATION NUMBER	LOCATION	MILEAGE INDEX	DESCRIPTION
1	Yellowstone River above Bear Creek	559.4	Cooke City Highway bridge east of Tower Junction.
2	Yellowstone River above Gardiner	537.0	At Gardiner water plant.
3	Yellowstone River below Gardiner	533.0	Two and one-half road miles below Gardiner along U.S. Highway 89.
4	Yellowstone River below Emigrant Creek	503.0	At Highway 89 bridge near Emigrant.
5	Yellowstone River above Fleshman Creek	480.5	At Livingston City Water Plant.
6	Fleshman Creek above Livingston and above Yellowstone River	480-5.0	Four road miles upstream from Livingston City limits (cemetary).
7	Fleshman Creek below Livingston and above Yellowstone River	480-1.0	At south 9th Street bridge in Livingston.
8	Yellowstone River below Fleshman Creek	476.8	East end of Lewis Street in Livingston.
9	Yellowstone River below Livingston Sewer Outlet	475.8	Above Highway 10-89 bridge and below Radio Station KDRK.
10	Yellowstone River below NPRR Waste Outlet	473.8	About two miles downstream from bridge along old U.S. Highway 89 and adjacent to Catholic Cemetary.
11	Yellowstone River at Springdale	454.0	County road bridge north of Springdale
12	Yellowstone River above Boulder River and above Big Timber	444.6	At county road bridge 6½ road miles southwest of Big Timber along U.S. Highway 10.
13	Boulder River above Yellowstone River and above Big Timber Sewage Lagoon	436.3-1.0	At U.S. Highway 10 bridge in Big Timber.

Appendix A (continued)

STATION NUMBER	LOCATION	MILEAGE INDEX	DESCRIPTION
14	Boulder River below Big Timber Sewage Lagoon and above Yellowstone River	436.3-0.4	About ¼ mile downstream from NPRR bridge.
15	Yellowstone River at Reedpoint	412.0	Near county road bridge on north side of Reedpoint.
16	Stillwater River above Columbus	396.3-1.0	At American Legion Stillwater Post #34 Camp Ground.
17	Yellowstone River above Columbus	397.0	At Columbus water plant intake.
18	Yellowstone River below Columbus	394.2	About ½ mile southeast of U.S. Government grain storage bins at east end of 3rd Avenue South in Columbus.
19	Yellowstone River above Laurel	367.2	At Laurel City Water Plant.
20	Clarks Fork of Yellowstone River above Chance	363.7-78.5	At historical stage coach station park site.
21	Clarks Fork of Yellowstone River above Bridger	363.7-50.0	U.S. Highway 310 bridge 2 miles above Bridger.
22	Clarks Fork of Yellowstone River below Bridger Sewer Outlet	363.7-40.0	Near J. F. Langendorf Ranch 3 miles above Fromberg.
23	Clarks Fork of Yellowstone River above Rock Creek	363.7-25.0	At county road bridge east of Edgar.
24	Rock Creek above Red Lodge	363.7-18.0-58.0	County road bridge 1 mile south of Red Lodge near veterinary hospital.
25	Rock Creek below Red Lodge	363.7-18.0-46.0	County road bridge near "Fox" 6 miles north of Red Lodge.
26	Rock Creek above Joliet	363.7-18.0-14.0	One mile upstream from Joliet near U.S. Highway 312 bridge.
27	Rock Creek below Joliet	363.7-18.0-4.2	County road bridge near Montequa 3½ miles northeast of Joliet

Appendix A (continued)

STATION NUMBER	LOCATION	MILEAGE INDEX	DESCRIPTION
28	Clarks Fork River above Yellowstone River	363.7-15	County road bridge near Silesia.
29	Yellowstone River below Laurel	363.0	One-half mile east of Laurel and 1 mile south of Allentown school.
30	Yellowstone River between Laurel and Billings	359.0	Six miles east of Laurel and 1 mile south of Canyon Creek School, near county road bridge.
31	Yellowstone River at Billings	348.0	Near Billings water treatment plant.
32	Yegen Ditch above Great Western Sugar Co. Waste Outlet	346.1-2.1	Intersection of State and South 27th Streets in Billings.
33	Yegen Ditch below Great Western Sugar Co. and above Conoco Oil Refinery Waste Outlet	346.1-1.5	About ½ mile upstream from Conoco Oil Refinery waste outlet at South 25th St. bridge.
34	Yegen Ditch below Conoco Oil Refinery Waste Outlets and above Meat Packing Plant Discharge	346.1-1.2	About 150 yards below Conoco Oil Refinery waste outlet.
35	Yellowstone River below Yegen Ditch and above Billings Sewer Outlet	345.7	Near Fairgrounds.
36	Yellowstone River below Billings sewage treatment plant	342.6	About 3 miles downstream from U.S. Highway 87 bridge at Billings and across from Humble Oil Refinery.
37	Yellowstone River at Huntley	334.7	U.S. Highway 10, 312 bridge at Huntley.
38	Yellowstone River at Worden	322.0	At John Mitzel Ranch north side of Worden.
39	Yellowstone River below Worden	315.0	County road bridge at Nibbe near Pompey's Pillar Park

Appendix A (continued)

STATION NUMBER	LOCATION	MILEAGE INDEX	DESCRIPTION
40	Yellowstone River between Pompey's Pillar and Custer	305.0	Fourteen road miles west of Custer near irrigation ditch headgate.
41	Yellowstone River above Big Horn River	283.6	County road bridge 1 mile north of Custer.
42	Big Horn River near Old Fort Smith	279.4-78.5	Forty-one miles south of Hardin including 10 miles beyond paved road and 2.4 miles along canal road.
43	Big Horn River above Little Big Horn River	279.4-40.0	Highway 87 bridge 2 miles east of Hardin.
44	Little Big Horn River above Big Horn River	279.4-40.0-0.5	County road bridge 2½ miles northeast of Hardin.
45	Big Horn River below Hardin and above Holly Sugar Co.	279.4-39.0	Near Holly Sugar Co. pumping plant about 1 mile downstream from Big Horn River and Little Big Horn River confluence in Hardin.
46	Big Horn River below Hardin and below Holly Sugar Co.	279.4-35.0	About 3 miles downstream from Holly Sugar Co. at Rexal Troth Ranch.
47	Big Horn River above Yellowstone River	279.4-1.0	At U.S. Highway 10,312 bridge near community of Big Horn.
48	Yellowstone River below Big Horn	268.0	County road bridge at Myers.
49	Yellowstone River above Hysham	263.5	About two and one-half miles west of Hysham water tower.
50	Yellowstone River below Hysham	259.0	One mile east and 1½ miles north of Hysham water tower.
51	Yellowstone River above Forsyth	232.0	At U.S. Highway 12 bridge.
52	Yellowstone River below Forsyth	222.0	Mouth of Wild Cat Coulee 5½ road miles east of Forsyth.
53	Yellowstone River above Miles City	181.8	At Miles City water treatment plant.

Appendix A (continued)

STATION NUMBER	LOCATION	MILEAGE INDEX	DESCRIPTION
54	Tongue River above Miles City Swimming Pool	181.5-5.0	At "N" Ranch 1 mile east and 4 miles south of Miles City.
55	Tongue River above Yellowstone River	181.5-0.5	Between highway and railroad bridges in Miles City.
56	Yellowstone River below Miles City	174.9	At Jones-Boschoe Ranch 5 miles northeast of Miles City.
57	Yellowstone River above Powder River	153.0	Near Benz (Zero) 11 miles west of Terry along U.S. Highway 10-94
58	Powder River above Yellowstone River	146.6-0.5	At U.S. Highway bridge on U.S. Highway 94 6 miles west of Terry.
59	Yellowstone River below Powder River and above Terry	141.0	At Milwaukee RR bridge about 4½ miles west of Terry.
60	Yellowstone River below Terry	129.0	About 5 miles downstream from Terry at river, railroad, and U.S. Highway 10 confluence.
61	Yellowstone River above Glendive	98.3	Near Sand Creek Coulee about 5 miles southwest of Glendive.
62	Yellowstone River below Glendive	87.0	Near U.S. Reclamation project at Deer Creek.
63	Yellowstone River above Sidney and above MDU plant	33.0	State Highway 23 bridge near MDU plant
64	Yellowstone River above Sidney and below MDU plant	30.3	Above Sidney sewer outlet.
65	Yellowstone River below Sidney	27.0	At Richland County Park, north of Sidney.

Appendix B.

CHEMICAL, PHYSICAL, AND BACTERIOLOGICAL DATA
OBTAINED DURING 1960 STREAM SURVEY ON THE
YELLOWSTONE RIVER DRAINAGE SYSTEM

Sta. No.	Date	Time	Stream Flow Cfs	Water Temp °F	Dissolved Oxygen ppm	Dissolved Oxygen % Sat.	pH	Total Alkalinity as ppm $CaCO_3$	Hardness	Chlorides ppm Cl^-	Sulphates ppm $SO_4^=$	Turbidity ppm	Bacteriological-Membrane Filter Coli. per 100 ml.	Bacteriological-Membrane Filter Bact. Date Taken	Bacteriological-Membrane Filter Time Taken	Bacteriological-Membrane Filter Sta. No.
1	6-21-60	11 AM		48°	7.8	80	7.1	40	26	5	6	<7	55	6-21-60	11 AM	1
2	6-21-60	4 PM	7,000*	50°	8.0	87	7.7	66	74	10	18	15	80	6-21-60	3 PM	2
3	6-22-60	9 AM	7,000*	48°	8.2	86	7.3	50	36	7	22	<7	295	6-22-60	9 AM	3
4	6-22-60	2 PM	8,000*	52°	7.8	84	7.3	46	54	7	14	10	74	6-22-60	1 PM	4
5	6-23-60	5 PM	8,100*	57°	8.4	95	7.5	60	62	6	2	10	24	6-23-60	3 PM	5
6	6-22-60	5 PM	12.3*	49°	8.0	83	8.1	218	212	6	2	75	297	6-23-60	3 PM	6
7	6-24-60	10 AM	12.3	54°	7.4	80	7.6	64	60	10	14	20	400	6-23-60	3 PM	7
8	6-24-60	8 AM	8,100*	53°	7.4	80	7.4	76	66	6	10	80	50 220	6-23-60 7-6-60	3 PM 5 PM	8
9	6-23-60	10 AM	8,100*	52°	7.8	83	7.5	60	54	13	6	25	5100	6-23-60	10 AM	9
10	6-23-60	1 PM	8,100*	55°	8.0	89	7.6	64	54	15	6	17	1200	6-23-60	3 PM	10
11	6-24-60	4 PM	8,100*	59°	7.8	90	7.7	72	62	11	6	9	535	6-27-60	8 AM	11
12	6-25-60	3 PM	8,100*	62°	7.8	92	7.7	66	62	9	8	<7	642	6-27-60	9 AM	12
13	6-25-60	11 AM	2,110	51°	7.8	81	7.4	50	46	4	14	50	125	6-27-60	9 AM	13
14	6-25-60	9 AM	2,110	51°	7.8	81	7.4	50	46	4	14	50	154	6-27-60	9 AM	14
15	6-25-60	1 PM	10,500*	61°	6.9	79	7.7	68	60	12	38	29	107	6-27-60	10 AM	15
16	6-27-60	3 PM	2,100*	60°	7.4	83	8.4	52	42	4	10	<7	630	6-28-60	8 AM	16
17	6-27-60	5 PM	10,500*	61°	7.4	84	8.4	70	58	9	24	<7	337	6-28-60	8 AM	17
18	6-27-60	1 PM	12,600*	64°	7.8	92	8.7	70	60	12	14	<7	888	6-28-60	8 AM	18
19	7-7-60	5 PM	5,000*	70°	7.1	90	8.8	92	110	15	12	15	80	7-7-60	1 PM	19
20	7-7-60	9 AM	1,100	58°	7.4	82	7.9	62	54	1	2	10	40	7-7-60	9 AM	20
21	6-29-60	2 PM	1,680*	60°	7.4	86	7.5	80	100	6	8	75	1850	6-29-60	9 AM	21
22	6-29-60	3 PM	1,680*	62°	7.1	84	7.9	80	88	6	12	80	100	6-29-60	9 AM	22
23	6-29-60	4 PM	1,680	64°	6.9	82	7.9	94	110	5	14	80	900	7-7-60	11 AM	23
24	6-28-60	12 N		51°	7.6	84	6.9	24	22	10	24	<7	28	6-29-60	7 AM	24
25	6-28-60	3 PM		57°	7.1	85	7.3	34	28	7	18	<7	65	6-29-60	7 AM	25
26	6-28-60	5 PM		72°	6.7	87	8.9	98	84	4	6	25	<3.3	6-29-60	8 AM	26
27	6-29-60	6 PM		68°	6.3	79	8.9	124	108	9	10	10	900	6-29-60	8 AM	27
28	7-8-60	12 N	2,000*	73°	7.8	102	8.9	138	186	14	22	90	30	7-7-60	12 N	28
29	7-8-60	2 PM	6,900*	73°	8.2	107	9.0	100	90	9	12	30	290	7-7-60	1 PM	29
30	7-8-60	3 PM	6,900*	71°	7.8	100	9.0	94	86	13	18	35	230	7-7-60	2 PM	30
31	7-9-60	5 PM	6,900	70°	8.0	100	9.0	106	104	13	18	15	60	9-8-60	11 AM	31
32	7-11-60	5 PM		71°	1.3	17	8.9	276	340	22	200	20				32
33	7-9-60	2 PM		73°	8.9	115	9.0	304	440	26	150	75				33
34	7-9-60	4 PM		65°				268	364	16	444	37	490	7-11-60	4 PM	34
35	7-9-60	11 AM	6,900	71°	6.5	82	9.0	106	102	13	18	50	45,000	9-8-60	1 PM	35
36	7-9-60	9 AM	6,900*	71°	6.7	85	9.0	98	102	13	18	30	10,900	7-11-60	9 AM	36
37	7-12-60	11 AM	6,000*	64°	7.5	90	9.1	100	108	17	20	45	4,000	9-8-60	2 PM	37
38	7-12-60	2 PM	6,000*	72°	8.8	113	9.0	104	112	45	38	50	7,000	9-11-60	10 AM	38
39	7-12-60	3 PM	6,000*	72°	8.6	110	9.0	108	118	18	18	55	4,000	9-11-60	11 AM	39
40	7-12-60	5 PM	6,000*	73°	7.8	100	9.0	108	120	13	34	50	920	7-14-60	6 PM	40
41	7-12-60	4 PM		72°	6.7	83	9.0	112	122	13	34	50	235	7-14-60	5 PM	41
42	7-14-60	9 AM	1,050*	72°	7.5	97	8.4	184	434	28	400	90	400	9-12-60	12N	42
43	7-14-60	1 PM	1,050*	74°	7.7	100	8.4	180	476	29	400	150	24,800	9-12-60	2 PM	43

Appendix B (continued)

Sta. No.	Date	Time	Stream Flow Cfs	Water Temp °F	Dissolved Oxygen ppm	Dissolved Oxygen Sat.	pH	Total Alkalinity as ppm $CaCO_3$	Hardness	Chlorides ppm Cl^-	Sulphates ppm $SO_4^=$	Turbidity ppm	Bacteriological-Membrane Filter Coli. Bact. per 100 ml.	Date Taken	Time Taken	Sta. No.
44	7-14-60	11 AM	31*	73°	6.8	87	8.3	270	444	25	160	80	2,300	9-12-60	2 PM	44
45	7-14-60	2 PM	1,080*	78°	7.7	91	8.5	220	512	35	496	300	30,000	7-14-60		45
46	7-14-60	3 PM	1,080*	78°	7.7	91	8.6	196	510	30	400	350	10,200	7-14-60		46
47	No station found for biological sample															47
48	7-14-60	4 PM	585	80°	7.9	109	8.7	216	540	41	240	400	80	9-11-60	2 PM	48
49	7-15-60	9 AM	5,600*	73°	6.4	82	8.6	128	168	15	60	30	200	9-11-60	3 PM	49
50	7-15-60	10 AM	5,600*	74°	6.6	86	8.8	130	172	19	64	50				50
51	7-15-60	12 N	5,600*	75°	7.2	94	8.8	136	164	19	170	150				51
52	7-15-60	2 PM	5,600*	78°	6.8	91	9.0	132	168	17	88	70	20	9-12-60	4 PM	52
53	7-15-60	3 PM	5,600*	78°	6.6	89	9.0	134	170	18	90	40				53
54	7-16-60	10 AM	5,600	77°	5.9	77	9.0	132	168	21	160	75	225	9-13-60	10 AM	54
55	7-16-60	9 AM	7.2	74°	5.9	75	8.5	406	490	18	340	300				55
56	7-16-60	11 AM	7.2*	80°	6.4	86	8.5	376	400	24	360	350	45,400	7-18-60		56
57	7-16-60	12 N	5,600	78°	7.7	102	9.0	160	196	20	156	60	11,800	7-19-60		57
58	7-19-60	11 AM	5,400*	78°	6.2	84	9.0	158	180	18	138	75				58
59	7-19-60	10 AM	16*	78°	6.0	78	8.7	206	912	180	300	250				59
60	7-19-60	9 AM	5,400*	77°	6.0	76	9.0	142	188	19	144	90	265	9-13-60	12 N	60
61	7-18-60	5 PM	5,400*	82°	6.2	86	9.0	138	180	23	140	75				61
62	7-18-60	4 PM	5,400*	81°	6.4	85	9.0	138	184	19	150	125	620	9-13-60	6 PM	62
63	7-18-60	2 PM	5,400*	87°	6.4	91	9.0	154	188	15	168	125				63
64	7-18-60	11 AM	4,480	78°	6.4	84	8.4	148	192	17	144	450	30	9-14-60	8 AM	64
65	7-18-60	9 AM	4,480*	76°	5.9	76	8.4	148	192	17	144	500				65
66	7-18-60	10 AM	4,480*	77°	6.1	78	8.5	148	192	19	144	700				66

* Estimated

Appendix C

Date of Collection, Number of Square Feet Stream Substrate Sampled, Number of Fish Collected, Number and Types of Invertebrates Collected, Total Invertebrates, Total Sensitive Invertebrates, Percent Sensitive Invertebrates, and Average Number of Invertebrates per Square Foot Collected from Stations Sampled in the Yellowstone River Drainage, Montana, during 1960.

Sta No.	Date	Square Feet Sampled	Types and Numbers of Organisms Collected[1]											Total	Total Sensitive	Invertebrates Percent Sensitive	Ave. No. per sq. ft.	Sta. No.
			Eph.	Plec.	Tric.	Odon.	Coleo.	Dipt.	Olig.	Hiru.	Gast.	Fish	Others[2]					
1	6-21-60	4	678	73	43	0	1	10	0	0	0	0	0	805	794	99	201	1
2	6-21-60	4	350*	40*	10*	0*	0*	1*	0*	0*	0*	0*	0*	401	400	99	100	2
3	6-22-60	4	272	107	4	0	6	16	0	0	0	0	0	405	383	95	101	3
4	6-22-60	4	240	171	100	0	1	12	0	0	0	0	0	524	511	97	131	4
5	6-23-60	4	246	21	598	0	0	4	0	0	0	0	0	869	865	99	217	5
6	6-22-60	4	64	5	1	0	8	8	0	0	35	0	1	122	70	57	31	6
7	6-24-60	4	23	7	61	0	19	250*	20	0	6	0	0	386	91	24	97	7
8	6-24-60	4	200*	40*	450*	0	0	0	0	0	0	0	0	690*	690*	100*	173*	8
9	6-23-60	4	336	41	42	0	0	6	1	0	6	2	0	432	419	97	108	9
10	6-23-60	4	329	10	116	0	0	16	0	0	1	0	0	472	455	97	118	10
11	6-24-60	4	179	8	390	0	0	4	0	0	47	1	0	629	577	92	158	11
12	6-25-60	4	70	11	52	0	0	1	0	0	0	0	0	134	133	99	33	12
13	6-25-60	4	104	2	412	0	0	2	0	0	1	0	0	521	518	99	130	13
14	6-25-60	4	400*	2	196	0	8	8*	0	0	0	0	0	614	598	97	154	14
15	6-25-60	4	52	10	5	1	0	2	0	0	0	0	0	70	67	96	18	15
16	6-27-60	4	310	3	124	0	6	31	0	0	2	0	0	476	437	92	112	16
17	6-27-60	4	523	20	88	0	3	71	5	0	0	0	0	710	631	89	178	17
18	6-27-60	4	186	13	21	1	0	18	0	0	27	1	0	267	220	82	67	18
19	7-7-60	4	325	4	83	0	0	21	1	0	2	0	0	436	412	94	109	19
20	7-7-60	4	32	0	8	0	0	0	0	0	0	0	0	40	40	100	10	20
21	6-29-60	4	407	3	69	1	0	16	1	0	6	0	2	505	479	95	126	21
22	6-29-60	4	386	2	15	1	0	18	0	0	2	0	0	424	403	95	106	22
23	6-29-60	4	41	0	19	0	0	4	0	0	0	0	0	64	60	94	16	23
24	6-28-60	4	176	26	186	0	27	50	0	0	0	0	4	469	388	83	117	24
25	6-28-60	4	307	3	242	0	0	259	0	0	0	0	0	811	552	68	203	25
26	6-28-60	4	617	1	341	0	10	92	8	0	6	1	0	1071	959	90	267	26
27	6-29-60	4	68	1	150	0	3	27	21	2	4	0	8	284	219	77	71	27
28	7-8-60	4	20	0	15	0	0	4	4	0	8	0	0	51	35	69	13	28
29	7-8-60	4	129	6	11	0	0	6	3	0	0	0	0	155	146	94	39	29
30	7-8-60	4	33	0	3	0	0	6	29	0	0	0	0	71	36	51	18	30
31	7-9-60	4	640	1	25	0	0	105	0	0	3	1	0	775	666	86	194	31
32	7-11-60	4	0	0	0	0	0	1500	0	0	0	0	0	1500	0	0	375	32
33	7-9-60	4	4	0	0	0	2	750*	35	0	0	0	2	793	4	1	198	33
34	7-9-60	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34
35	7-9-60	4	2	0	1	0	0	4	9	0	0	0	0	16	3	19	4	35
36	7-9-60	4	58	0	10	0	0	25	8	0	1	0	0	102	68	67	26	36
37	7-12-60	4	105	0	2	0	0	106	38	0	0	1	0	252	107	42	63	37
38	7-12-60	4	18	0	0	0	0	18	15	0	0	0**	0	51	18	36	13	38

Eph. = Ephemeroptera; Plec. = Plecoptera; Tric. = Trichoptera; Odon. = Odonata; Coleo. = Coleoptera; Dipt. = Dipteria; Olig. = Oligochaeta; Hiru. = Hirudinea; Gast. = Gastropoda

Includes Amphipoda, Arachnida, Decapoda, Hemiptera, Isopoda, Nematoda, and Turbellaria

Estimated number - too numerous to count, or small forms escaped in debris.

*Many large forms observed.

Appendix C (continued)

Sta. No.	Date	Square Feet Sampled	Types and Numbers of Organisms Collected											Total	Total Sensitive	Invertebrates Percent Sensitive	Invertebrates Ave.No. per sq. ft.	Sta. No.
			Eph.	Plec.	Tric.	Odon.	Coleo.	Dipt.	Olig.	Hiru.	Gast.	Fish.	Others					
39	7-12-60	4	0	0	0	2	0	0	175	0	1	0	0	178	0	0	44	39
40	7-12-60	4	106	0	0	0	0	20	51	0	0	0	0	177	106	60	44	40
41	7-12-60	4	32	0	0	2	0	10	10	0	0	0	0	54	32	59	14	41
42	7-14-60	4	24	0	150	10	0	45	0	0	0	0	0	229	174	76	57	42
43	7-14-60	4	9	0	12	0	0	21	0	0	0	0	0	42	21	50	11	43
44	7-14-60	4	39	0	69	0	0	25	0	0	0	0	0	133	108	81	33	44
45	7-14-60	4	15	0	24	0	0	28	0	0	0	0	0	67	39	58	17	45
46	7-14-60	4	4	0	43	0	0	8	0	0	0	0	0	55	43	85	14	46
47	7-14-60	4	No Collection Taken															47
48	7-14-60	4	18	0	128	0	0	28	0	0	0	0	1	175	146	83	44	48
49	7-15-60	4	13	0	2	0	0	15	14	0	0	0	0	44	15	34	11	49
50	7-15-60	4	2	0	0	0	0	4	12	0	0	0	0	18	2	11	5	50
51	7-15-60	4	70	0	10	0	0	8	4	0	3	0	0	95	80	84	24	51
52	7-14-60	4	19	0	3	0	0	10	6	0	0	0	0	38	22	58	10	52
53	7-15-60	4	110	0	33	0	0	12	2	0	0	0	0	157	143	91	39	53
54	7-16-60	4	28	0	0	0	1	0	0	0	0	0	0	29	28	97	7	54
55	7-16-60	4	10	0	6	0	0	16	0	0	0	0	0	32	16	50	8	55
56	7-16-60	4	No Collection Taken															56
57	7-16-60	4	14	0	0	0	0	6	10	0	3	0	0	33	14	42	8	57
58	7-19-60	4	1	0	0	0	0	4	17	0	0	0	0	22	1	5	6	58
59	7-19-60	4	4	13	239	3	0	4	0	0	0	0	0	263	256	97	66	59
60	7-19-60	4	102	0	5	3	0	5	0	0	0	0	0	115	107	93	29	60
61	7-18-60	4	815	0	150	0	0	12	0	0	3	0	0	980	965	99	245	61
62	7-18-60	4	340	0	40	0	0	2	0	0	0	0	0	382	380	99	95	62
63	7-18-60	4	14	0	6	0	0	6	0	0	0	0	0	26	20	77	7	63
64	7-18-60	4	80	0	14	0	0	3	0	0	0	0	0	97	94	97	24	64
65	7-18-60	4	No Collection Taken															65
66	7-18-60	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66

MONTANA STATE WATER POLLUTION COUNCIL
STREAM CLASSIFICATION
FOR
YELLOWSTONE RIVER AND LITTLE MISSOURI RIVER DRAINAGE AREAS OF THE MISSOURI RIVER

BODY OF WATER ORDER[1]							
Second	Third	Fourth	Fifth	LOCATION[2]	PRESENT USE	REMARKS	CLASSIFICATION
Missouri	Yellowstone			Above Gardiner	WSp, F&R, IW		A,C,D,E
		Gardiner		Above Gardiner	WSp, F&R, PS, WP		A,C,D,E
		All	All	Gardiner to Shielde River	WSo, Ag, F&R		A,C,D,E
	Yellowstone			Gardiner to Shielde River	WSp, PS, IW, Ag, F&R	Sewage from Gardiner & Livingston, Ind. Waste. NP	B,C,D,E
		Shields River	All	Yellowstone to source	Ag, F&R, WSo		A,C,D,E
	Yellowstone			Shields River to Boulder River	Ag, F&R, PS		B,C,D,E
		Boulder River		Yellowstone to source	WSp, Ag, F&R		A,C,D,E
	Yellowstone			Boulder River to Stillwater Rv.	Ag, F&R, Ps		B,C,D,E
		Stillwater River		Yellowstone to source	PS, Ag, F&R, IW, WSo	Possible wastes from mines in upper watershed. Imhoff tank Absarokee	A,C,D,E
	Yellowstone			Stillwater River to Clark's Fork River	WS, PS, Ag, IW, F&R	Sewage from Columbus. WSp Laurel	B,C,D,E
		Clark s Fork		Yellowstone to Montana State Line	WSp, PS, IW, Ag, F&R	Possible coal mine drainage	B,C,D,E
			Rock Creek	Clarks Fork to W. Fork	WSp, Pe, IW, Ag, F&R	Waste Ponds at Red Lodge -Imhoff tank at Joliet	B,C,D,E
			Rock Creek	W. Fork to source	WSp, Ag, F&R		A,C,D,E
			W. Fork Rock Creek	Rock Creek to source	WSp, Ag, o, F&R	WSp - Red Lodge	A,C,D,E
	Yellowstone			Clarks Fork to Tongue	WSpi, Ag, IW, PS, o	WSp-Billings, Humble, Forsyth, Miles City, PS Billings, Laurel, Forsyth-IW Humble, Continental, Meat Packing, Sugar Factory. Fish have phenolic tasts.	B,C,D,E
		Big Horn		Yellowstone to Montana State Line	WSp, Ag, IW, PS, F&R	Wsp Hardin, PS Hardin, IW Holly Sugar	B,C,D,E
			Little Big Horn	Big Horn to Montana State Line	WS, PS, Ag, F&R	WS Custer Battlefield, Crow Agency, Wyola	B,C,D,E
		Gt. Porcupine Creek		Yellowstone to source	Ag, F&R	May be used as domestic water supply	A,C,D,E
		Rosebud Creek		Yellowstone to source	Ag, F&R	May be used as domestic water supply	A,C,D,E
		Tongue		Yellowstone to Montana State Line	Ag, F&R	May be used as domestic water supply	B,C,D,E
		Sunday		Yellowstone to source	Ag, F&R		B,C,D,E
			Louie & Scottie	Sunday Creek to source	Ag, F&R		B,C,D,E
		Powder		Yellowstone to Montana State Line	Ag, PS, F&R	Broadus Sewage	B,C,D,E
			Mizpah	Powder to source	Ag, F&R		B,C,D,E
			Little Powder	Powder to Montana State Line	Ag, F&R		B,C,D,E
		O'Fallon		Yellowstone to source	Ag, F&R		B,C,D,E
	Yellowstone			Tongue to Montana State Line	WSpoi, Ag, IW, PS	WSp-Glendive-PS, Miles City, Glendive, Sidney, Fairview, IW-N.P.-Holly Sugar	B,C,D,E
	Little Mo.			SE Montana	Ag, F&R		B,C,D,E
		Box Elder		Montana Line to Source	Ag, F&R		B,C,D,E
		Beaver Creek		Montana Line to Source	Ag, F&R, PS	Wibaux Sewage	B,C,D,E

All tributaries not listed above should have at least the same classification as the next larger stream into which they discharge.

[1] a first-order stream is one which terminates at the ocean (consequently, we have no 1st-order streams in Mont.) 2nd-order are tributary to 1st. etc.
[2] at confluence with stream of next largest order listed above
WS Water Supply, (p) Public, (i) Industrial, (o) Private or Resort, WP Water Power, PS Public Sewage, IW Industrial Waste, Ag Agriculture, F&R Fishing and Recreation

Adopted by Montana Water Pollution Council
Health aspects approved by Montana State Board of Health September 2, 1958
Printed June 1, 1961.

Appendix E

STATE OF MONTANA WATER POLLUTION COUNCIL

STREAM CRITERIA FOR WASTE DISCHARGES

WATER QUALITY OBJECTIVES AND MINIMUM TREATMENT REQUIREMENTS FOR MONTANA SURFACE AND UNDERGROUND WATERS

WATER QUALITY WATER USES	ORGANISMS OF THE COLIFORM GROUP	FLOATING, SUSPENDED SETTLEABLE SOLIDS AND SLUDGE DEPOSITS	TASTE OR ODOR PRODUCING SUBSTANCES	DISSOLVED OXYGEN	pH	TOXIC, COLORED, OR OTHER DELETERIOUS SUBSTANCES	PHENOLIC COMPOUNDS	OIL	HIGH TEMPERATURE WASTES	MINIMUM TREATMENT REQUIREMENTS FOR DOMESTIC SEWAGE
(A) WATER SUPPLY, DRINKING, CULINARY, AND FOOD PROCESSING. Without treatment other than simple disinfection and removal of naturally present impurities.	Most probable number (MPN) coliform bacterial content of a representative number of samples should average less than 50 per 100 ml. in any month.	None attributable to sewage, industrial wastes, or other wastes which, after reasonable dilution and mixture with receiving waters, interfere with the best use of these waters for the purpose indicated.	None attributable to sewage, industrial wastes or other wastes.	Greater than five (5) parts per million, except for underground waters.	Hydrogen ion concentration expressed as pH should be maintained between 6.5 and 8.5	None alone or in combination with other substances or wastes in sufficient amounts or of such nature as to make receiving water unsafe or unsuitable for use indicated (U. S. P. H. S. Stds)	Less than five (5) parts per billion	None	Not in sufficient quantities alone or in combination with other wastes to interfere with the use indicated.	Primary treatment and effective disinfection except in special cases as determined by the State Board of Health. Sewage lagoon treatment will meet this requirement.
(B) WATER SUPPLY, DRINKING, CULINARY, AND FOOD PROCESSING. With treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary for removing naturally present impurities	MPN coliform bacterial content of a representative number of samples should average less than 2000 per 100 ml. and should not exceed this number in more than 20 percent of samples examined in any month where associated with domestic sewage.	(Same as for use "A" above).	None attributable to sewage, industrial wastes or other wastes which, after reasonable dilution and mixture, will increase the threshold odor number above eight (8).	Same as for use "A" above.	Same as for use "A" above.	Same as for use "A" above.	Same as for use "A" above.	None detectable	Same as for use "A" above.	Same as for use "A" above.
(C) BATHING, SWIMMING, AND RECREATION. Note: When waters are used for recreational purposes such as fishing and boating, exclusive of bathing and swimming, the number "1000" may be substituted for "240" in statement of coliform objectives.	MPN coliform bacterial content of a representative number of samples should average less than 240 per 100 ml. and should not exceed this number in more than 20 percent of samples examined in any month where associated with domestic sewage.	Same as for use "A" above.	None attributable to sewage, industrial wastes or other wastes which, after reasonable dilution and mixture, will interfere with the best use of these waters for the purpose indicated.	Greater than five (5) parts per million.	Same as for use "A" above.	Same as for use "A" above.	Less than twenty five (25) parts per billion or none in sufficient amounts as to impart a residual taste to recreational or commercial fish or other aquatic forms	Same as for use "B" above.	Same as for use "A" above.	Same as for use "A" above.
(D) GROWTH AND PROPAGATION OF FISH AND OTHER AQUATIC LIFE. Including waterfowl, furbearers, and other aquatic and semi-aquatic life.	See note under "C" above.	Same as for use "A" above.	None attributable to sewage, industrial wastes or other wastes which will interfere with the palatability or propagation of recreational or commercial fish or other edible aquatic forms.	Same as for use "C" above.	Same as for use "A" above.	None alone or in combination with other substances or wastes in sufficient amount or of such character as to make receiving waters unsafe or unsuitable for use indicated.	Same as for use "C" above.	Same as for use "B" above	Not in sufficient quantity as to increase the temperature of the receiving water beyond that optimum for the normal aquatic life of the specific water.	Primary treatment and effective disinfection. Sewage lagoon treatment will meet this requirement.
(E) AGRICULTURAL AND INDUSTRIAL WATER SUPPLY Without treatment except for the removal of natural impurities to meet special quality requirements other than those classified under "A" above. Note: Permissible limits for total concentration percent sodium, boron, chlorides, and sulphates to receive further study, suggested value for percent sodium is less than 40. Percent sodium computed as the ratio of sodium to total cations expressed in equivalent weights. Calculated from the formula: Na X 100 + Na + K + Ca + Mg when Na, Ca, K, and Mg are expressed in equivalents.		Same as for use "A" above	None attributable to sewage, industrial wastes or other wastes which will adversely affect the marketability of agricultural or industrial produce.	Greater than three (3) parts per million.	Hydrogen ion concentration expressed as pH should be maintained between 6.0 and 9.5	Same as for use "A" above.	None in sufficient quantity as to make receiving water unsuitable for use indicated.	Same as for use "B" above	Same as for use "A" above.	Same as for use "D" above.

Water Quality Objectives of a watercourse will apply at the point of discharge of a waste except in special cases where the sampling points will be determined by the Montana Water Pollution Council.

Determinations in the above table will be in accordance with "Standard Methods for the Examination of Water, Sewage and Industrial Wastes".

Adopted tentatively Feb. 28. 1956
Revised April, 1958
Reviewed Sept. 2, 1958